

REPUBLIC OF BURUNDI
IGEBU: INSTITUT GEOGRAPHIQUE DU BURUNDI

THE STUDY ON
ESTABLISHING DIGITAL TOPOGRAPHIC DATABASE FOR
BUJUMBURA CITY, BURUNDI

Final Report
(Manuals)

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JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

PASCO CORPORATION

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Aerial Triangulation

The Basic Theory of Aerial Triangulation

<Objective>

To calculate orientation parameters for establishing stereo models using the attitude ($\kappa \cdot \phi \cdot \omega$) and position ($X \cdot Y \cdot Z$) of each aerial photo. The attitude and position are calculated by analyzing software with the data such as control points.

1. Planning

Index map that principal points of aerial photos, location of control points, leveling routes and so on are drawn shall be prepared. And the time schedule shall be created under consideration of necessary date, assignment of operators and so on.

The following items shall be considered during planning.

- A) The terrains of work area.
- B) The vegetation of work area.
- C) The density of settlement of work area.
- D) Experience of assigned engineer.

2. Preparation

2.1 Required equipments, documents and data for this work are followings.

- A) DPW (Digital Photogrammetric Workstation)
- B) Software for aerial triangulation
- C) Calibration report of camera which was used for aerial photography
- D) Image files
- E) Photo index map
- F) Data of exposure station, time, angle and so on (in the case of aerial photography by GPS/IMU)
- G) Description of control points (data of control points)

Notice : About mentioned on D), the direction of photos should be consistent and **right** angle to the flight direction.

2.2 Generation of image files

Image files shall be generated depending on the supported format in software used

2.3 Creation of control point file

Control point file (above-mentioned on G) shall be prepared depending on the supported format in software used

Notice : In the case of manual input of control point file, the errors such as type miss should be checked after input. .

2.4 Creation of Camera file

Camera file shall be created by inputting camera calibration data (**Focal length, Principal Point coordinate, Image size, Pixel size**)

Notice : In the case of manual input of above-mentioned information, the errors such as type miss should be checked after input.

3. Observation of “Pass points”, “Tie Pints”, “Control Points”

The observation of images should be conducted according to following steps.

Common points must be observed in order to associate with the images of the same course and adjacent course. Generally, common points of same course is called pass points, common points of adjacent course is called tie points.

3.1 Observation of pass point

- ◇ More than 3 points shall be observed in an image. (Point A, Point B, Point C)
- ◇ “Point B” shall be located on the center of image.
- ◇ “Point A” shall be located **7~8 cm** above the “Point B”. (right angle to the flight direction)
- ◇ “Point C” shall be located **7~8 cm** under the “Point B”. (right angle to the flight direction)
- ◇ Points shall be located in the area where is clear and flat and lapped by 3 consecutive images (in the case of more than 60% overlap).

3.2 Observation of tie point

Points shall be located in the area where is clear and flat and shall be observed more than 1 point in a model. To improve the connectivity of courses, the location of tie points shall be “Zigzag” arrangement. (in the case of more than 30% sidelap)

Notice : In the case of using automatic-stereomatching function for observation that without distinction between pass points and tie points, the visual check for the number and location of points and the result of auto-matching should be conducted. The area such as forest area and desert area where the auto-matching is difficult because of color toneless should be checked carefully. The errors should be fixed by re-observation or moving points manually.

3.3 Observation of control point

Control points shall be observed after opening the models that the control points or elevation points as a result of minor leveling should be. This observation should be conducted carefully by referring description of control point and pricking photos.

In case that the points are between adjacent courses, the same method shall be applied.

Notice : In the case of incomplete model which is difficult to observe points because of sea or huge lakes, it is possible to observe points on the sea-level or water surface as the reference point for elevation.

EX Sea-level surface = 0m Water surface of lake A = 35.5m

However, the sea-level surface has tidal difference, therefore the target map scale should be concerned.

4. Adjustment

Geodetic coordinate shall be calculated from image coordinate through the Helmert's transformation with the adequate parameter after the input of observed image coordinate of pass points, tie points, control points and control point file (In case of using GPS/IMU, data of exposure station, time, attitude and camera calibration) into analyze software.

And then, following outputs shall be calculated.

<Discrepancy>

Connection discrepancy: Discrepancy about the connection on the same course or the connection between adjacent courses.

Control point discrepancy: Discrepancy to calculated value from control points (Control point residual).

<Orientation parameter>

The attitude ($\kappa \cdot \phi \cdot \omega$) and the position ($X \cdot Y \cdot Z$) of each image.

5. Check

The results of adjustment should be checked. In case the value is over the limitation value, the observation should be continued until the value is within the limitation value.

5.1 Check result for “Pass points” and “Tie Points”

Check the result whether standard deviation and max of discrepancy of pass points, tie points are within the tolerance.

Calculation	Tolerance
Standard Deviation	within 0.015mm
Max	within 0.03mm

5.2 Check result for “Control points”

Check the result whether standard deviation and max of control point residual are within the tolerance.

Calculation		Tolerance
Standard Deviation	X	less than “altitude above ground level” x 0.02 %
	Y	less than “altitude above ground level” x 0.02 %
	Z	less than “altitude above ground level” x 0.02 %
Max	X	less than “altitude above ground level” x 0.04 %
	Y	less than “altitude above ground level” x 0.04 %
	Z	less than “altitude above ground level” x 0.04 %

6. Quality Control

Orientation file which is calculated by adjustment shall be imported into DPW with image files and then stereo models shall be established. After establishing stereo models, the following contents shall be checked. During checking, in case the value is over the limitation value, the re-observation should be conducted until the value is within the limitation value.

1. There is no the vertical parallax more than 20 μ m in each model.
2. Measuring the same point between models on the same course or between adjacent courses to check the connection.
3. Measuring the control points. And the value of the horizontal (X, Y), vertical (Z) and discrepancy shall be checked

The Basic Manipulation of Aerial Triangulation Software

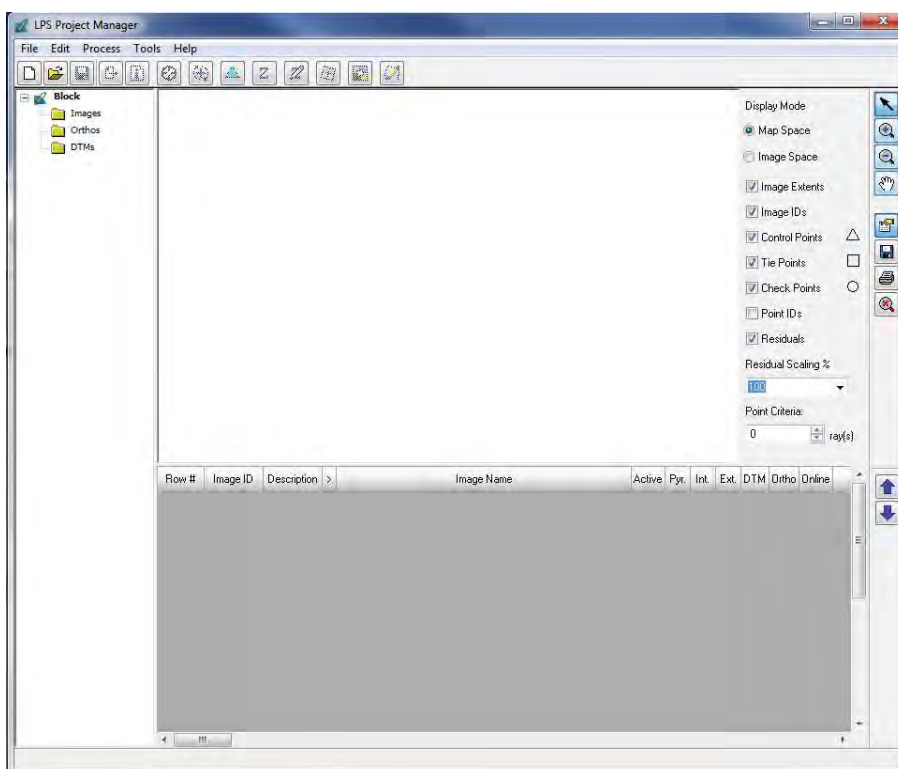
<Objective>

This manual makes user appreciate the each steps and contents easily, although a lot of images generally shall be used in general project. Moreover, although there are various options and parameters in each step, any typical options and parameters are selected in each step in this manual.

1. Create a New Block File

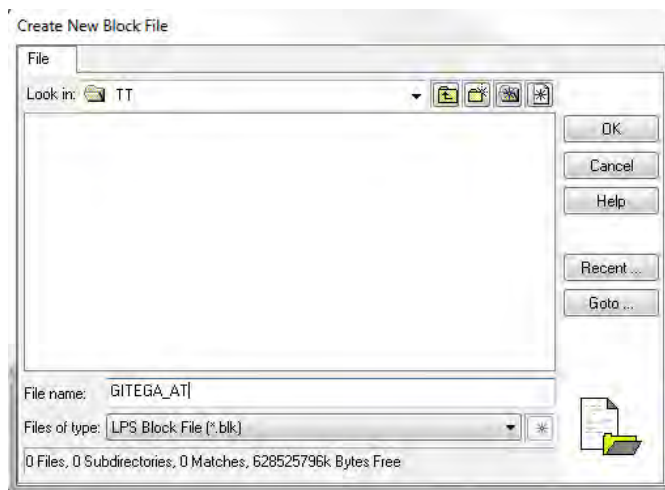
1.1 Open LPS

Double click this icon or select “Leica photogrammetry Suite” from the Windows program then The “Project Manager” window appears.



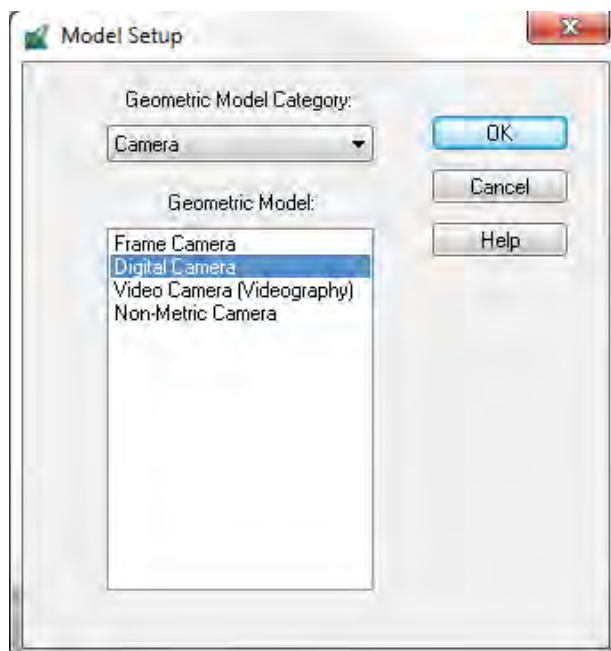
1.2 Create New “Block file (*.blk)”

Click the following icon then Move into folder and type new file name. And click “OK”.

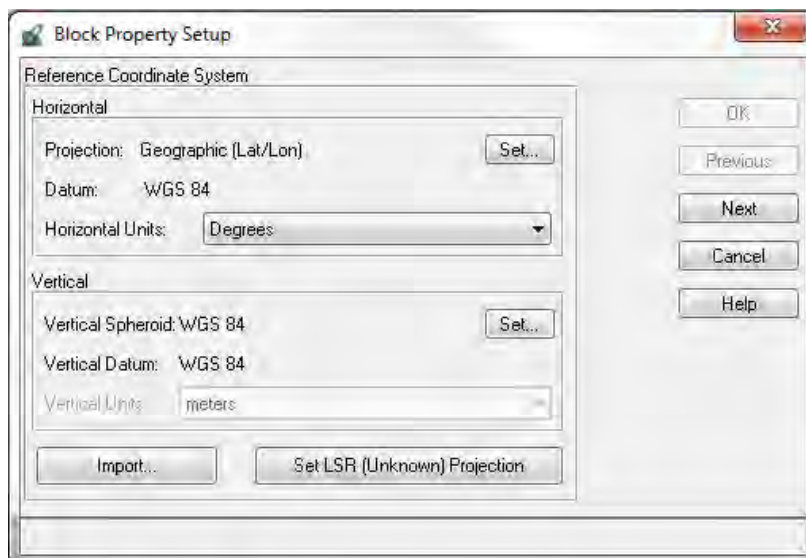


1.3 Model Set up(Camera type, Coordinate System)

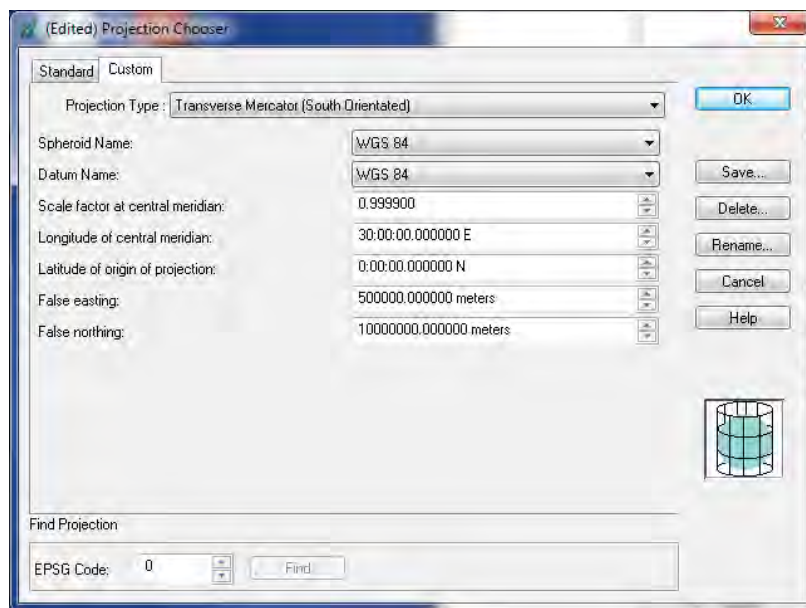
The “Model Setup” window appears then select “Camera” at the “Geometric Model Category:” and select “**Digital Camera**” at the “Geometric Model Category: Camera” and then click “OK”.



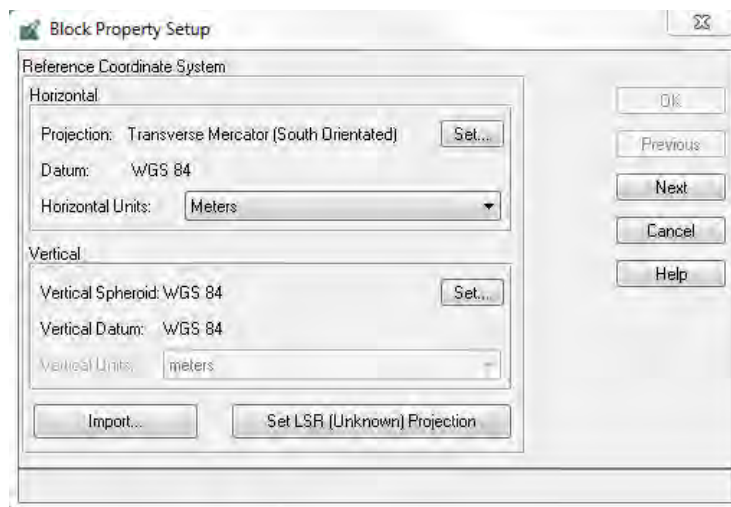
The “Block Property Setup” window appears. Click “Set...” at “Horizontal”.



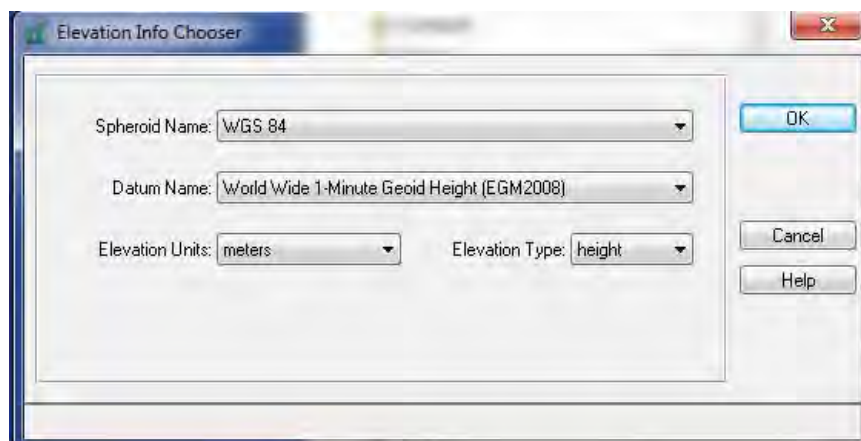
In the “Project Chooser” window, click the “Custom” tag and set each value as follow, then click “OK”.



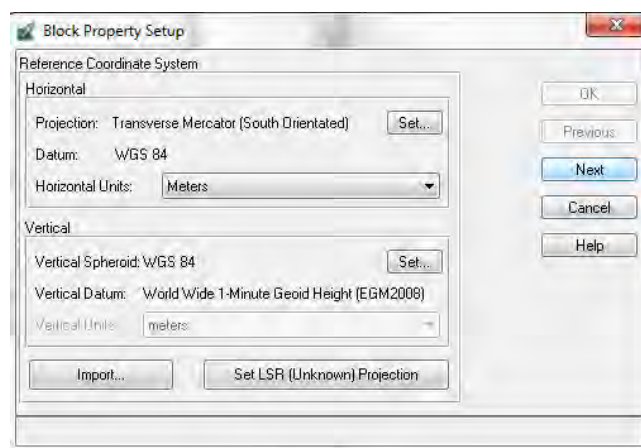
After “Horizontal” setting, Click “Set...” at “Vertical”.



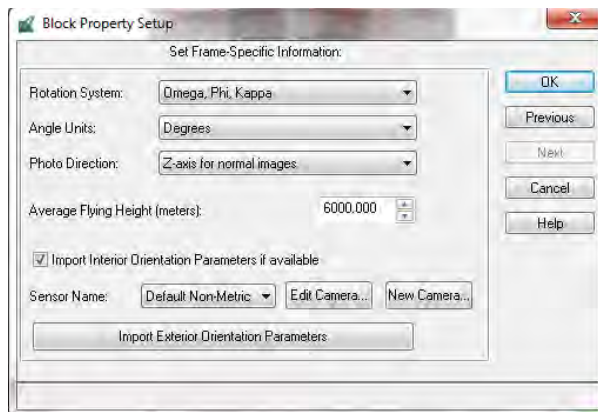
In the “Elevation Info Chooser” window, choose “Spheroid” and "Datum" as follow, then click “OK”.



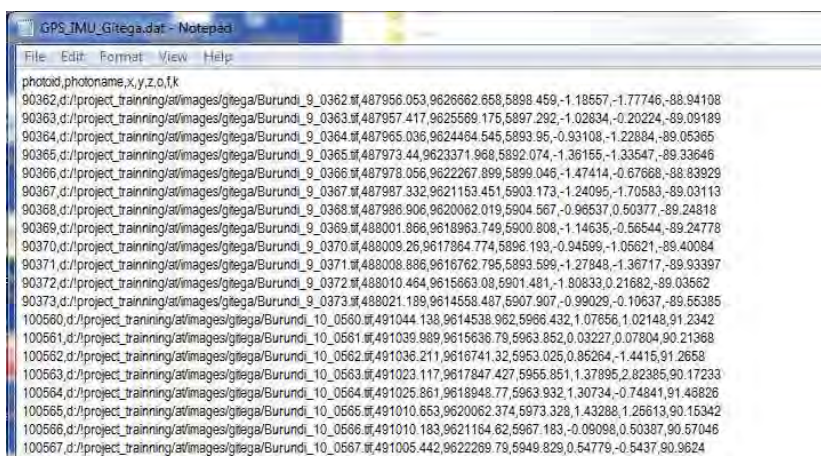
Confirm the coordinate system and click “Next”.



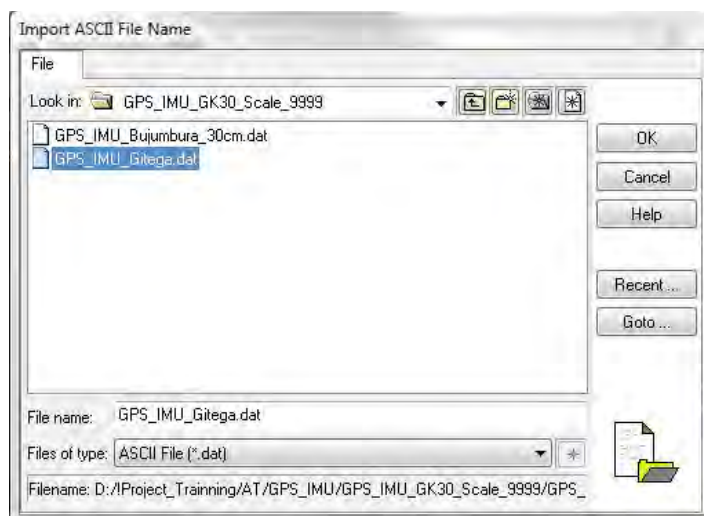
Set any information as shown below. The value of “Average Flying Height” of aerial photography is input. And click “OK”.



Import GPS/IMU data with click on "Import Exterior Orientation Parameters".

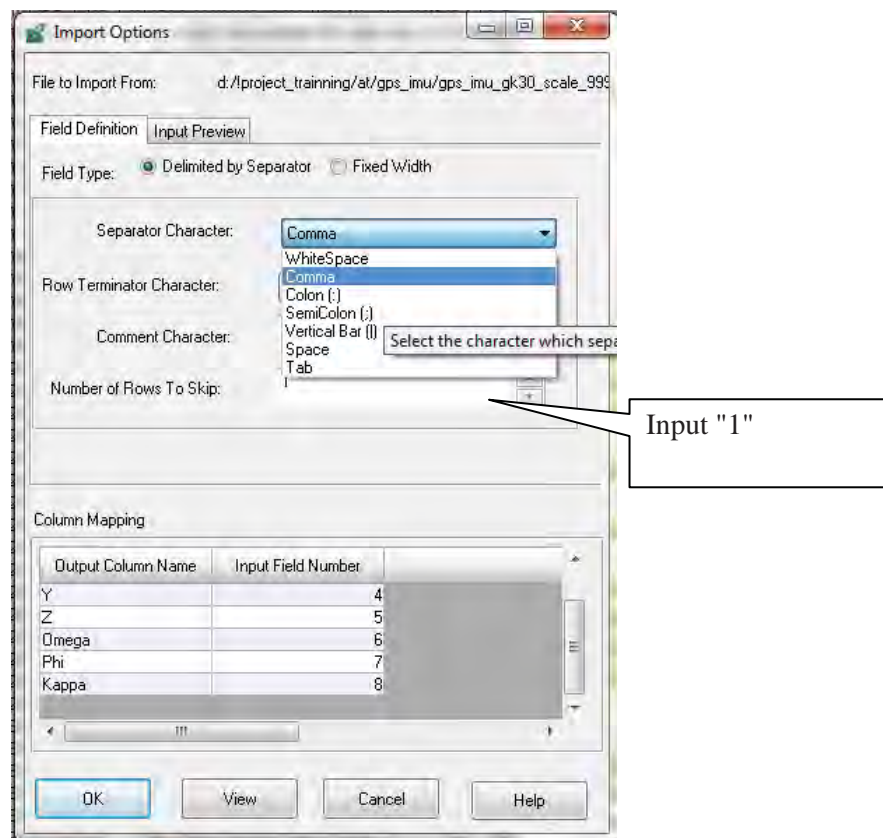


Move into folder which contains GPS/IMU file and choose GPS/IMU file then click “OK”.

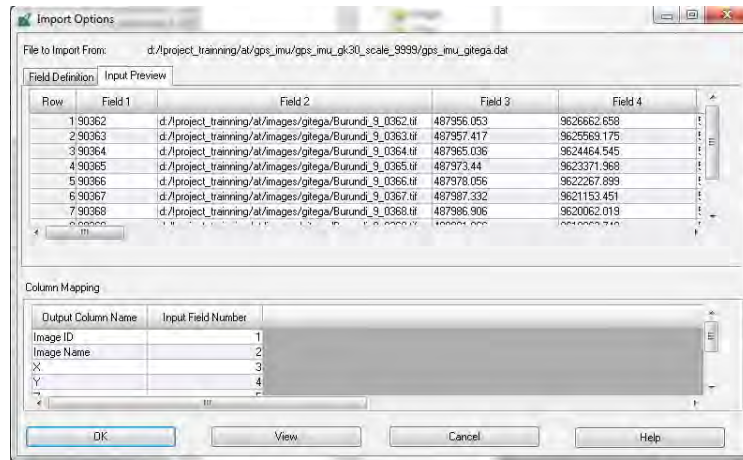




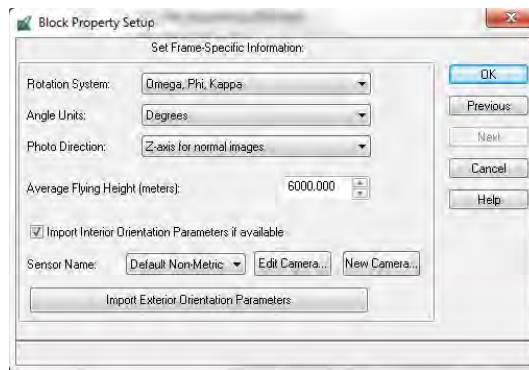
Choose "Comma" as the Separator Character In the "Field Definition" tag.



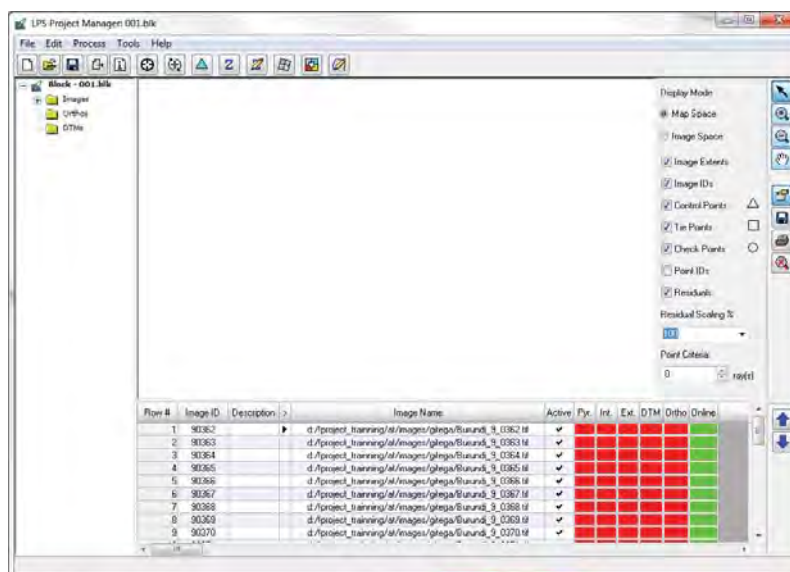
Verify the result of “Field Definition” setting in “Input Preview” tag. If the result is good, click "OK"



Click "OK" in the "Block Property Setup" Window.



If the import of GPS/IMU succeeded, the main window looks as follow and all images has been imported automatically.



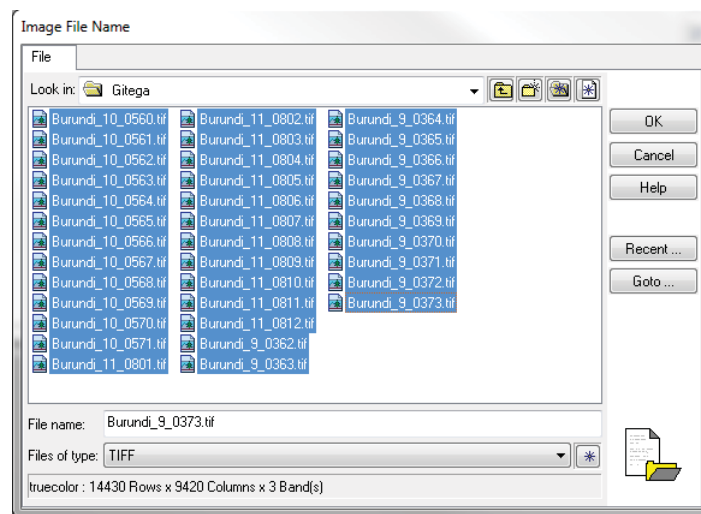
2. Add image to the block file

2.1 Add image files

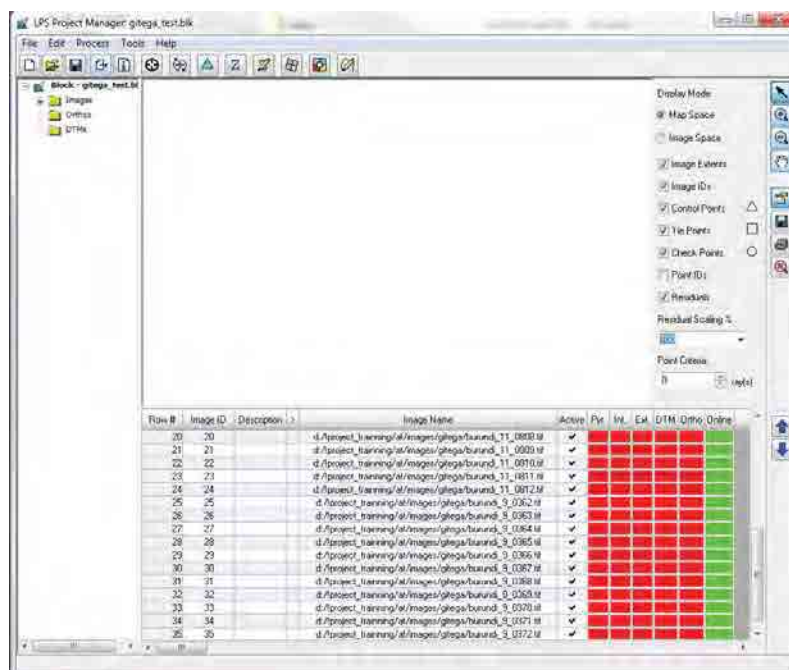
In case of the images were not imported in previous step or no GPS/IMU, Click following icon in the “Project Manager” window to open images.



In the “Image File Name” window, select appropriate image after moving to folder where images are stored. Select appropriate file type at “Files of type:” and click “OK”.



The “Project Manager” is displayed as shown below.



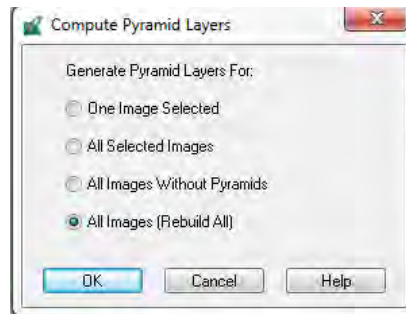
2.2 Computation of pyramid layers

To create the pyramid layer, click column of “Pyr.” as shown below.

Image Name	Active	Pyr.	Int.	Ext.	DTM	Ortho	Online
ect_training/at/images/gitega/burundi_11_0808.tif	✓	■	■	■	■	■	■
ect_training/at/images/gitega/burundi_11_0809.tif	✓	■	■	■	■	■	■
ect_training/at/images/gitega/burundi_11_0810.tif	✓	■	■	■	■	■	■
ect_training/at/images/gitega/burundi_11_0811.tif	✓	■	■	■	■	■	■
ect_training/at/images/gitega/burundi_11_0812.tif	✓	■	■	■	■	■	■
ect_training/at/images/gitega/burundi_9_0362.tif	✓	■	■	■	■	■	■
ect_training/at/images/nitega/burundi_9_0363.tif	✓	■	■	■	■	■	■

Point Criteria:
0 ray(s)

The “Compute Pyramid Layers” window appears. Select the “All Images Without Pyramids” and click “OK”.

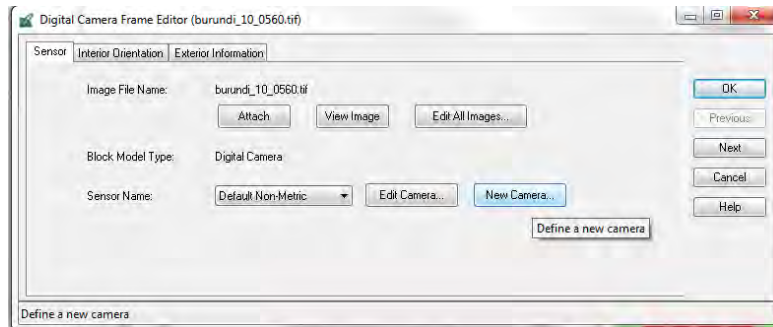


After completing generating pyramid layers, color of column of “Pyr.” turns to green from red.

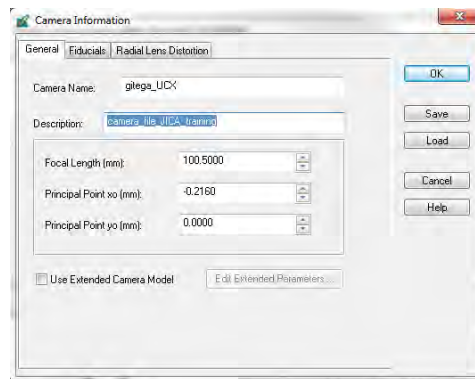
Row #	Image ID	Description	Image Name	Active	Pyr.	Int.	Ext.	DTM	Ortho	Online
10	10		d:\project_training/at/images/gitega/burundi_10_0569.tif	✓	■	■	■	■	■	■
11	11		d:\project_training/at/images/gitega/burundi_10_0570.tif	✓	■	■	■	■	■	■
12	12		d:\project_training/at/images/gitega/burundi_10_0571.tif	✓	■	■	■	■	■	■
13	13		d:\project_training/at/images/gitega/burundi_11_0801.tif	✓	■	■	■	■	■	■
14	14		d:\project_training/at/images/gitega/burundi_11_0802.tif	✓	■	■	■	■	■	■
15	15		d:\project_training/at/images/gitega/burundi_11_0803.tif	✓	■	■	■	■	■	■
16	16		d:\project_training/at/images/gitega/burundi_11_0804.tif	✓	■	■	■	■	■	■
17	17		d:\project_training/at/images/gitega/burundi_11_0805.tif	✓	■	■	■	■	■	■
18	18		d:\project_training/at/images/gitega/burundi_11_0806.tif	✓	■	■	■	■	■	■
19	19		d:\project_training/at/images/gitega/burundi_11_0807.tif	✓	■	■	■	■	■	■
20	20		d:\project_training/at/images/gitega/burundi_11_0808.tif	✓	■	■	■	■	■	■
21	21		d:\project_training/at/images/gitega/burundi_11_0809.tif	✓	■	■	■	■	■	■

3. Camera File Setting (Creation)

Click following icon then "Frame Camera Frame Editor" window appears. To create a camera file, click "New Camera...".



Fill "General" tag referring "Camera Calibration Report" then "Save" and "OK".



VEXCEL
UltraCamX, Serial Number UCX-SX-1.90517585

Panchromatic Camera

Large Format Panchromatic Output Image

Image Format	long track	67.824mm	9420pixel
	cross track	103.896mm	14430pixel
Image Extent		(-33.91, -51.95)mm	(33.91, 51.95)mm
Pixel Size		7.200µm*7.200µm	
Focal Length	ck	100.500mm	± 0.002mm
Principal Point (Level 2)	X ppa	0.000 mm	± 0.002mm
	Y ppa	0.216 mm	± 0.002mm
Lens Distortion	Remaining Distortion less than 0.002mm		

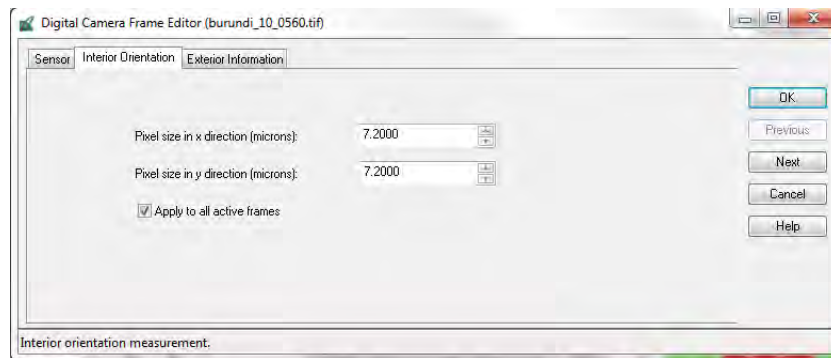
Multispectral Camera

Medium Format Multispectral Output Image
(Upscaled to panchromatic image format)

Image Format	long track	67.824mm	3140pixel
	cross track	103.896mm	4810pixel
Image Extent		(-33.91, -51.95)mm	(33.91, 51.95)mm
Pixel Size		21.600µm*21.600µm	
Focal Length	ck	100.500mm	
Principal Point (Level 2)	X ppa	0.000 mm	± 0.002mm
	Y ppa	0.216 mm	± 0.002mm
Lens Distortion	Remaining Distortion less than 0.002mm		

Input the Pixel size of the camera(from "Camera Calibration Report") in the "Interior Orientation"

tag.



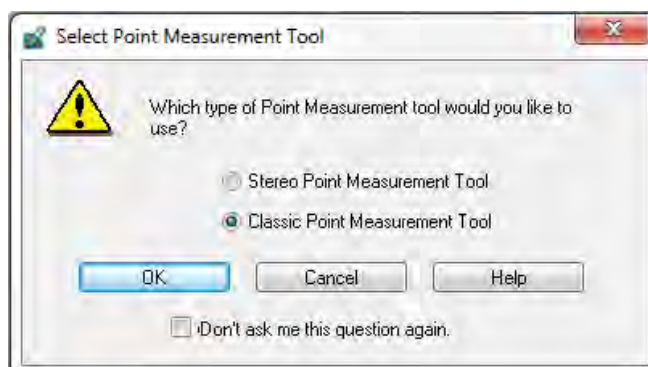
If camera file has already created, it is possible to load it by clicking “Load”.

4. Observation of GCPs

1. Click this icon in the “Project Manager” window.

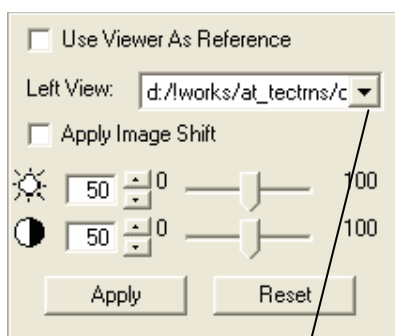


2. The “Select Point Measurement Tool” window appears. Select “Classic Point Measurement Tools” and click “OK”.

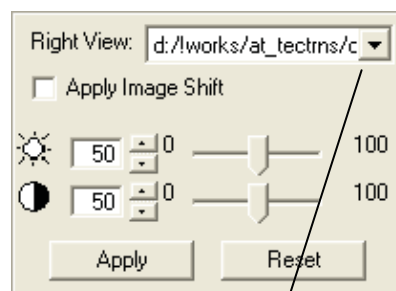


3. The “Point Measurement” window appears as shown below.

It is possible to change left and right image file at the following palette at the right side of the “Point Measurement” window.
























The left image is selegable at here.

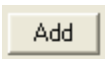

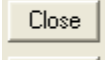
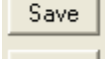
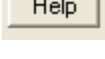


The right image is selegable at here.

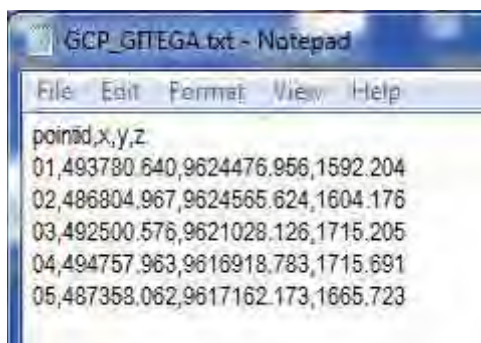
This is tool palette.



				
Select point	Create point	Keep current tool	Reset screen	Undo point measurement
				
Perform automatic tie generation	Automatic tie properties	Perform triangulation	Triangulation properties	Report of triangulation results
				
Set automatic (x,y) drive	Update Z values on selected points	Set automatic Z value updating	Reset horizontal reference source	Reset vertical reference sources
				
Compute image coordinates from the ground points	Triangulate a new ground control point	Compute ground positions for selected tie points	Import or export points	Select points which are common to both left and right viewers
				
Viewing properties				

	—	Add new point
	—	Delete selected points
	—	Close point measurement tool
	—	Save current block
	—	Point measurement tool help

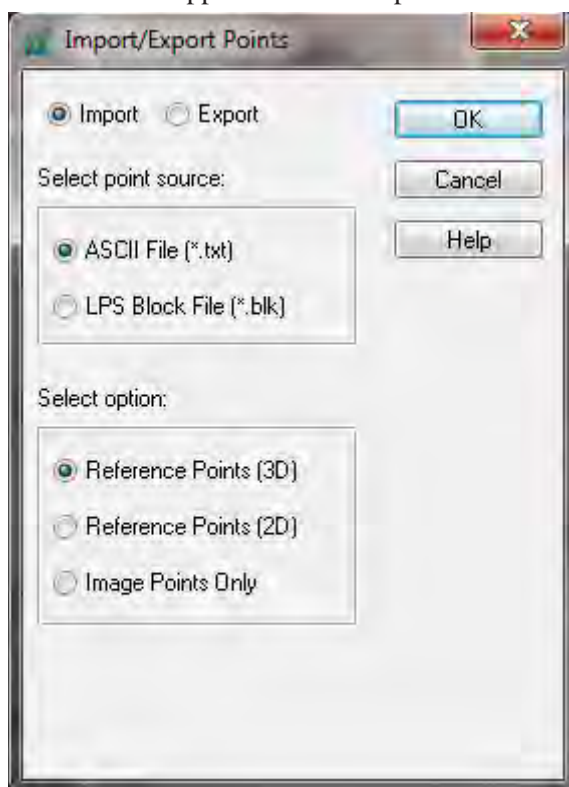
4. In this manual, it assumes that a control file is prepared as text file as shown below. The coordinate system is same with the “block file”.



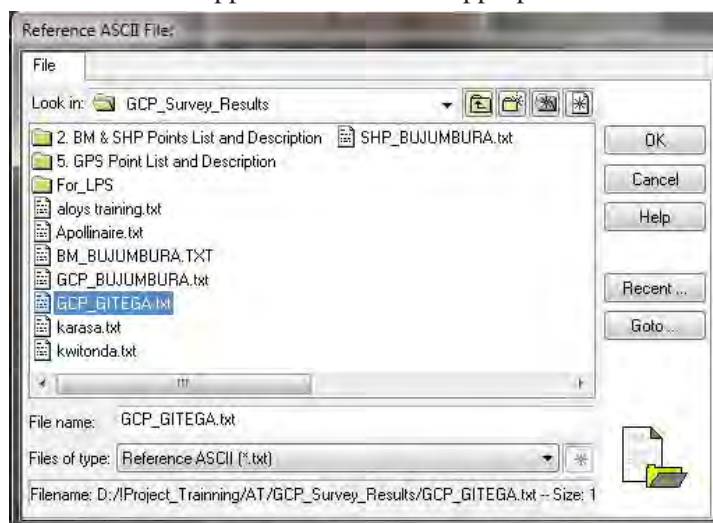
5. Click this icon in the tool palette.



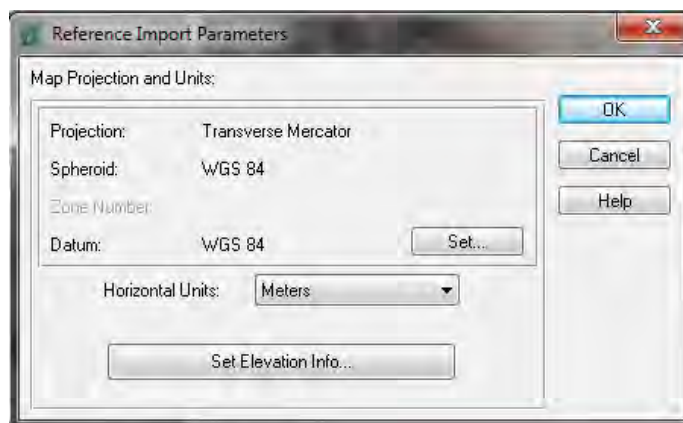
6. The “Import/Export Points” window appears. Select options as shown below and click “OK”.



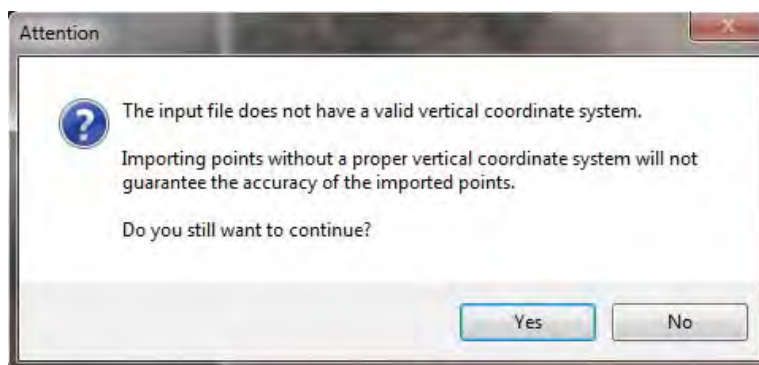
7. “Reference ASCII file:” window appears. Select the appropriate file and click “OK”.



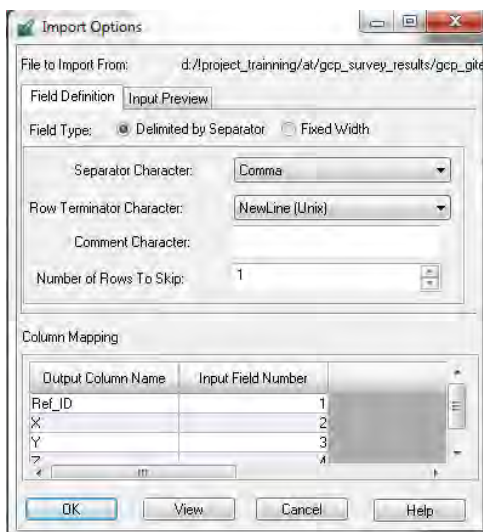
8. The “Reference Import Parameters” window appears. In this window, map projection and units are set as shown below. And click “OK”.



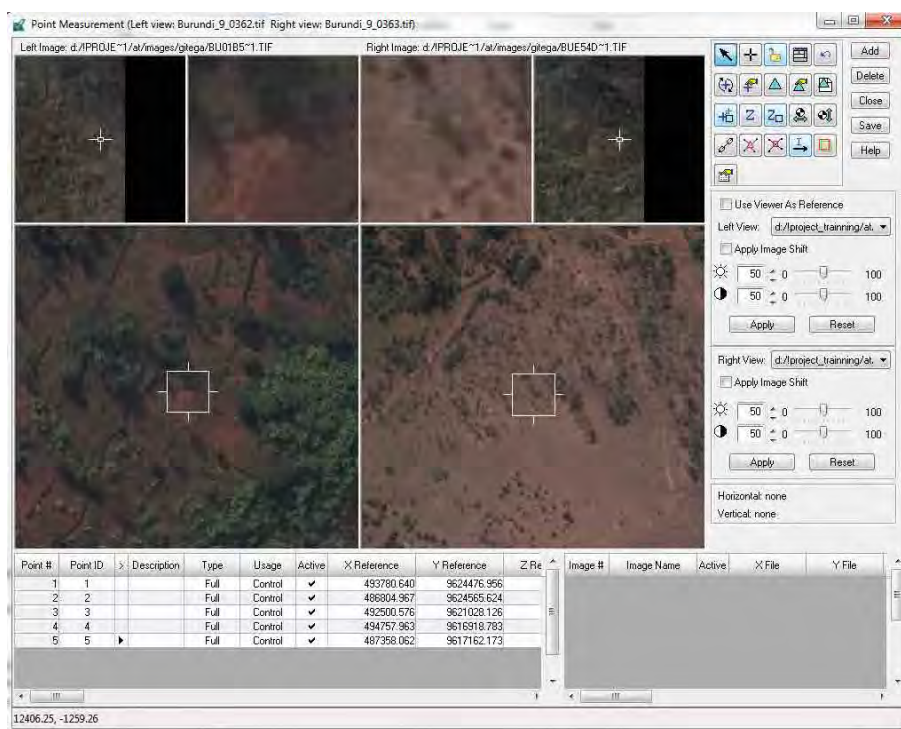
9. Although the “Attention” window appears, click “Yes”.



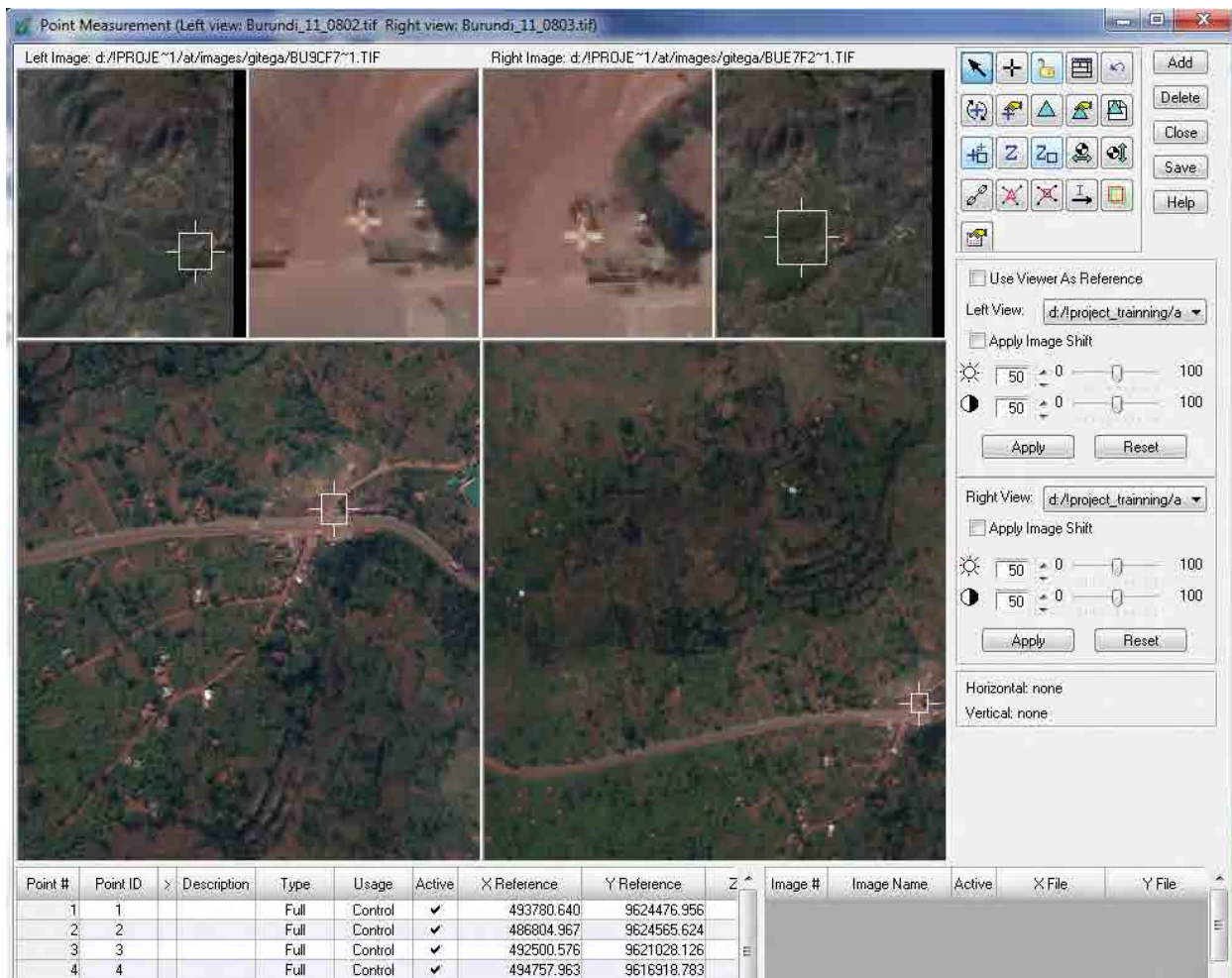
10. The “Import Options” window appears. Set any options as shown below and click “OK”.



11. The coordinate values of GCPs are loaded as shown below.



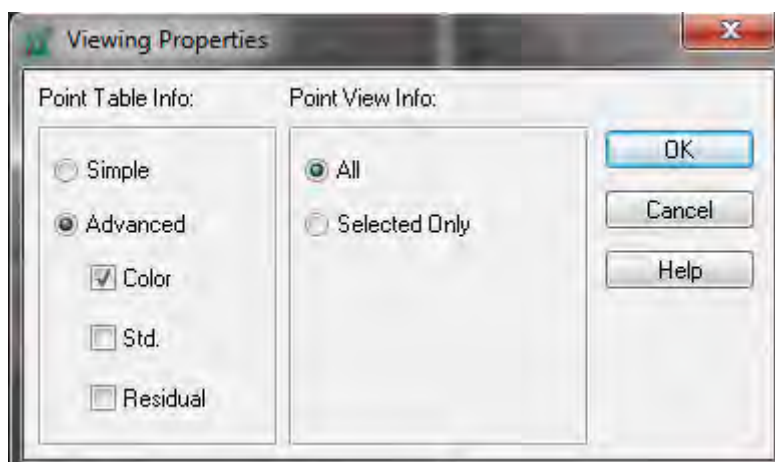
12. Move to the location of GCP 1 by moving the geographic link box.



By clicking this icon, it is possible to add a column of color.



Select “Advanced” and “Color” in the “Viewing Properties”. And click “OK”.



13. Click this icon to start observation of GCPs. Mouse cursor shall be changed.



14. GCP is observed on every appropriate photo images in reference to description of control point. (In this manual, description of control point indicate **Appendix**) This is case of GCP 1. Because GCP 1 must be on 3 images as shown in **Appendix**, name of 3 images is listed in the column of “Image Name” as shown below.

Image #	Image Name	Active	X File	Y File
1	Burundi_11_0802	✓	8017.786	7695.146
2	Burundi_11_0803	✓	4649.300	7821.476
3	Burundi_11_0804	✓	1095.636	7730.494

15. If this icon is on, the geographic link box shall move automatically to rough corresponded location after more than 3 points are observed on each image.



16. After the observation of GCPs, click “Save”.

17. It is possible to change the type of GCPs and usage of points as necessary.

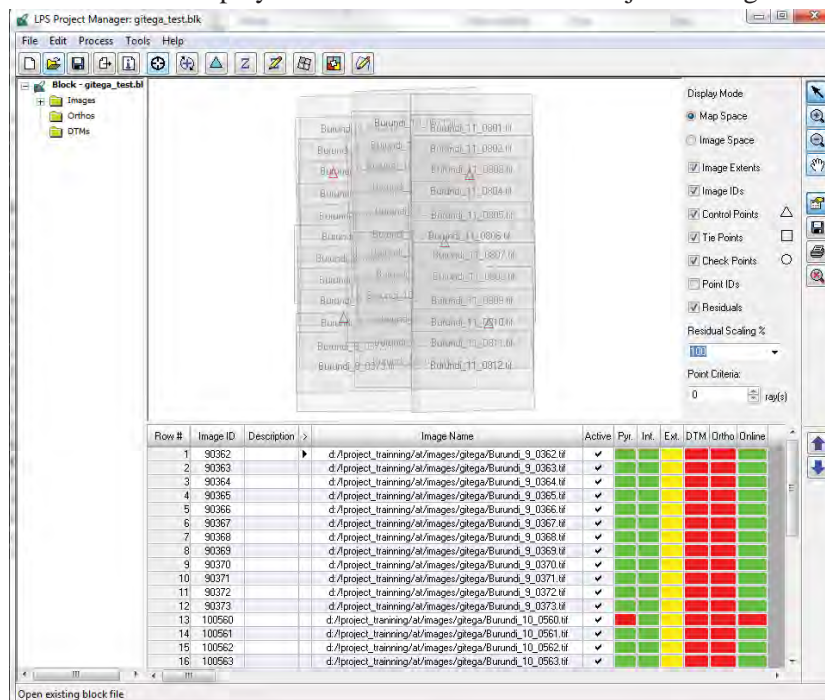
"Lmb" on column of “Type”, it is possible to change the type.

Point #	Point ID	Description	Type	Usage	Active	X Reference	Y Reference	Z
1	1		Full	Control	✓	493780.640	9624476.956	
2	2		Full		✓	486804.967	9624565.624	
3	3		Full		✓	492500.576	9621028.126	
4	4		Full		✓	494757.963	9616918.783	
5	5		Full		✓	487358.062	9617162.173	

"Lmb" on column of “Usage”, it is possible to change the usage type.

Point #	Point ID	Description	Type	Usage	Active	X Reference	Y Reference
1	1		Full	Control	<input checked="" type="checkbox"/>	493780.640	9624476.956
2	2		Full	Contr	<input checked="" type="checkbox"/>	486804.967	9624565.624
3	3		Full	Contr	<input checked="" type="checkbox"/>	492500.576	9621028.126
4	4		Full	Contr	<input checked="" type="checkbox"/>	494757.963	9616918.783
5	5		Full	Contr	<input checked="" type="checkbox"/>	487358.062	9617162.173

18. Location of GCPs shall be displayed as shown below in the “Project Manager” window.

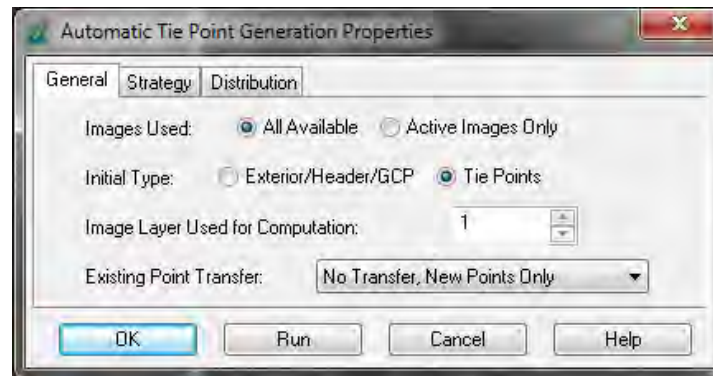


5. Generation of automatic tie point

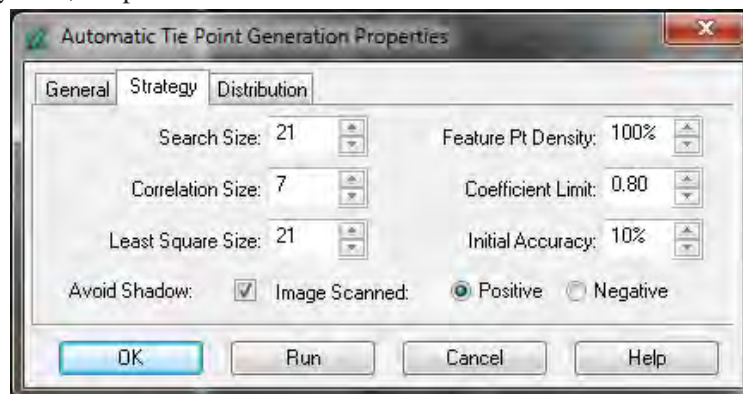
1. Click this icon in the “Point Measurement” window to generate tie points. In this software (LPS), both tie points and pass points are called tie points.



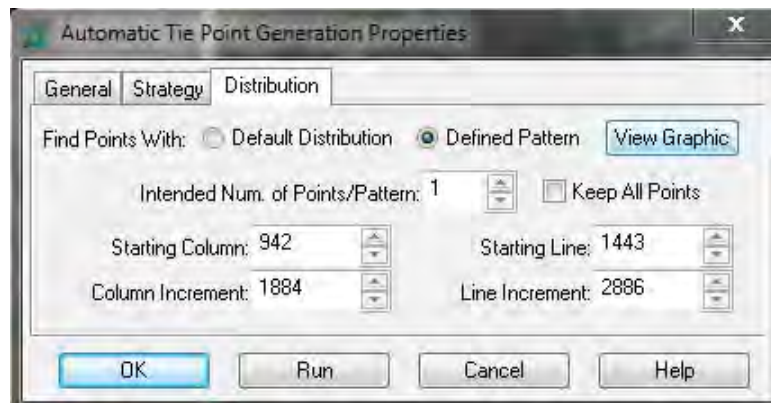
2. The “Automatic Tie Point Generation Properties” window appears. In the “General” tab, set options as shown below.

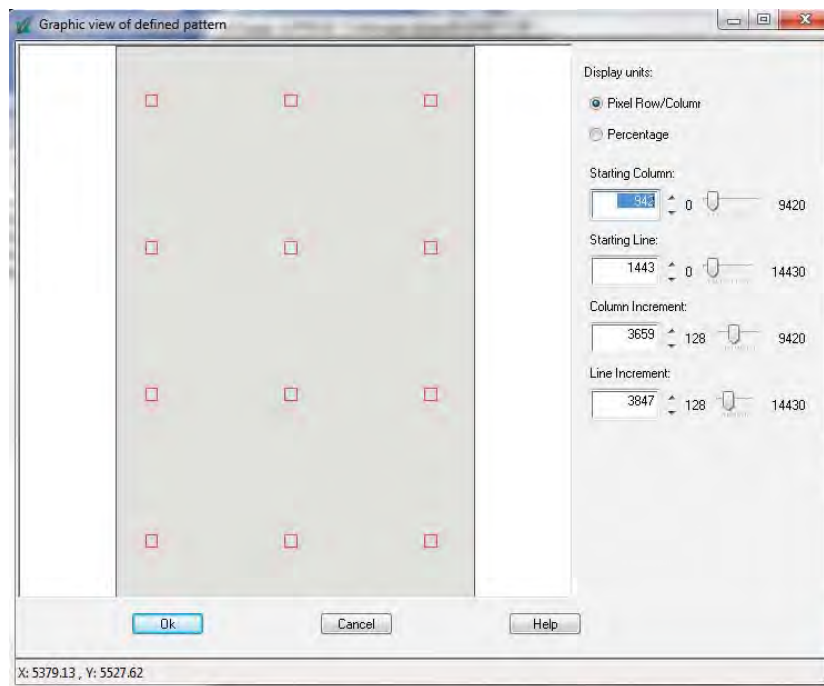
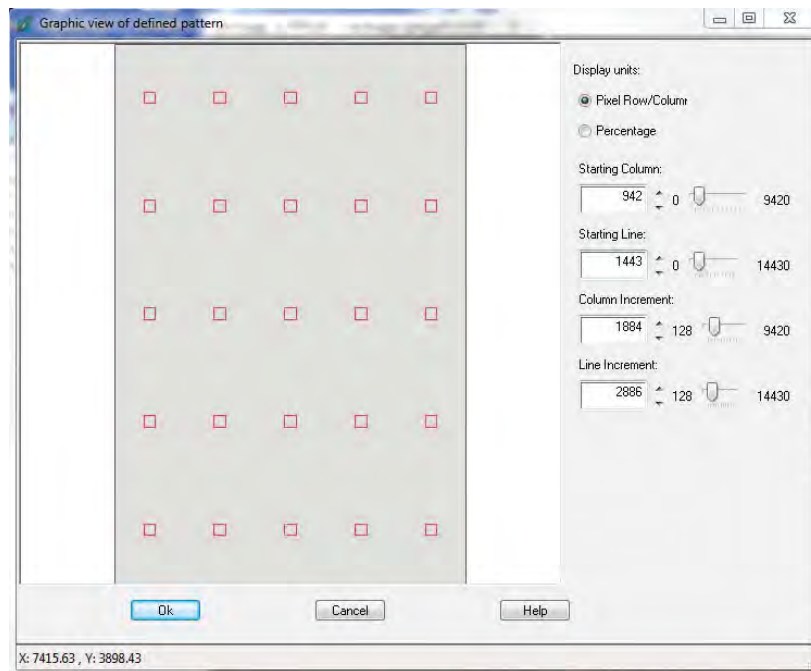


3. In the "Strategy" tab, set parameters as shown below.

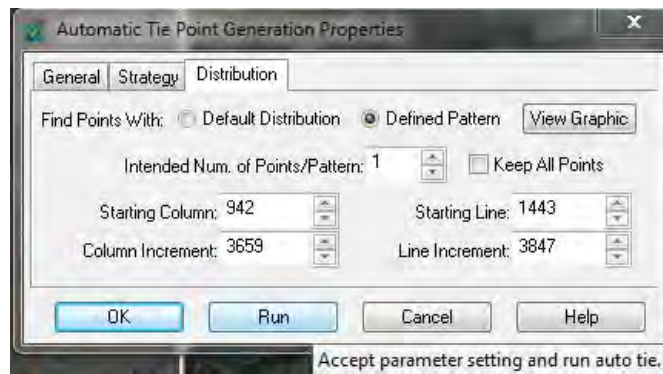


4. Click the "Distribution" tab. In case of the visual check of the layout of tie points, "Lmb" "View Graphic". also number of tie points and the layout are able to be changed.

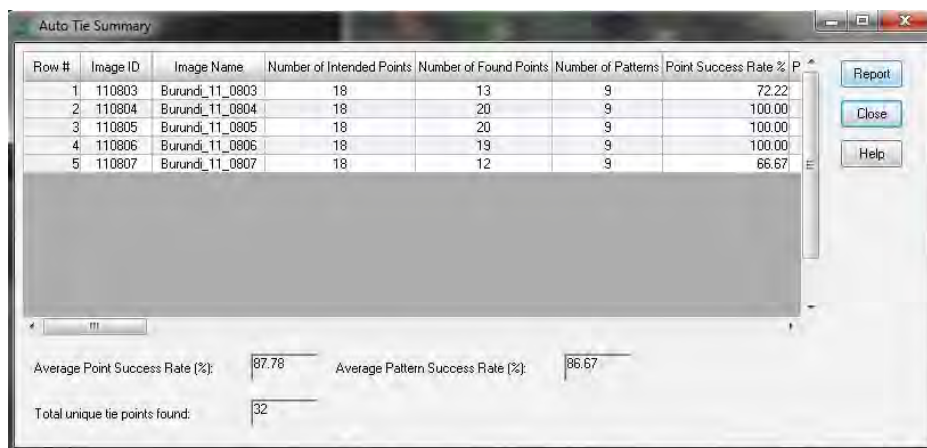




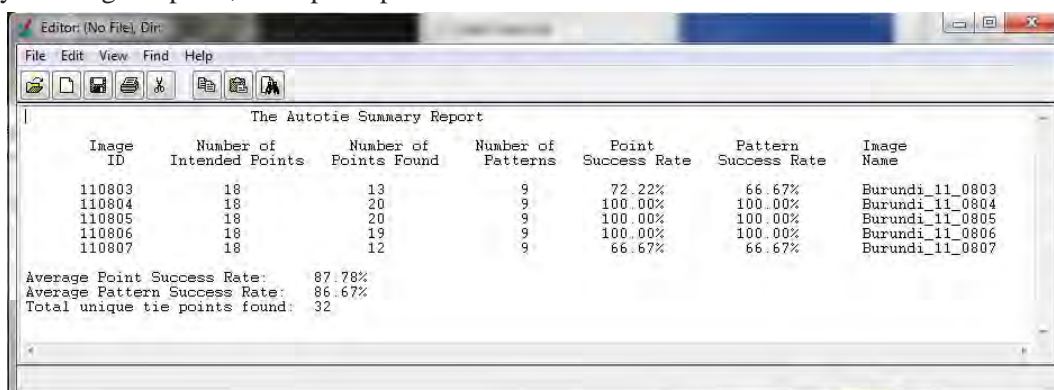
5. Set parameters in the “Distribution” tab as shown below. And click “Run”.



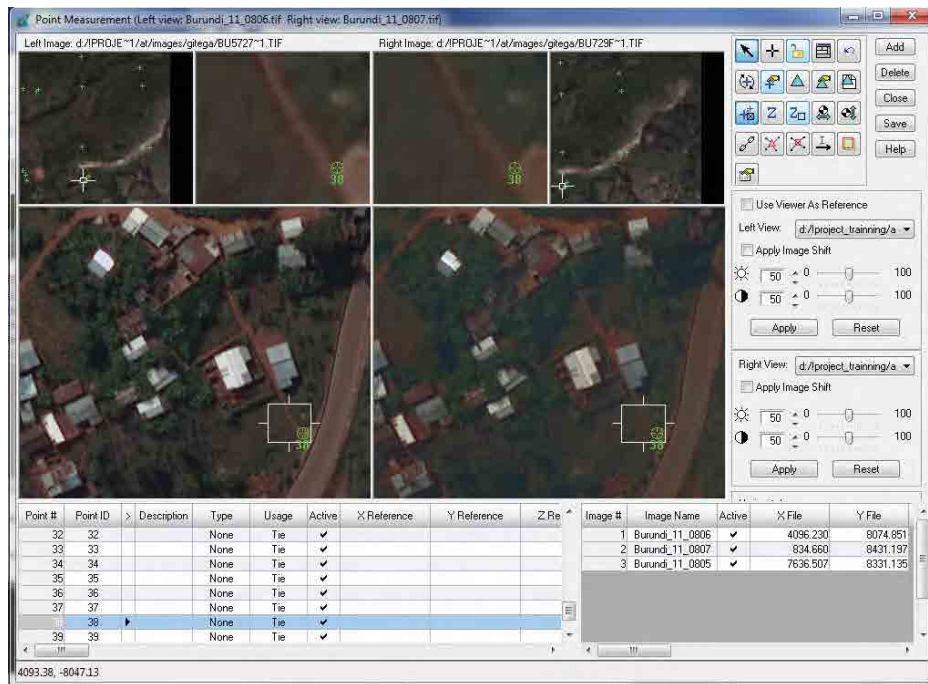
- The “Auto Tie Summary” window appears and the result of automatic tie points generation is shown.



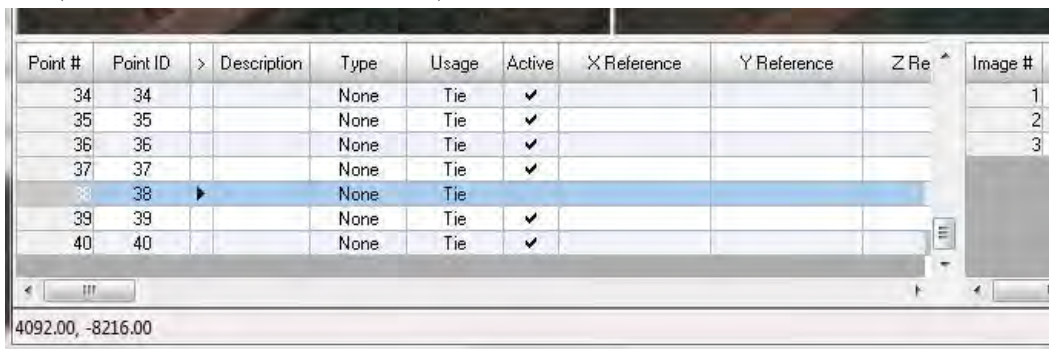
- By clicking “Report”, the report opens



- In the “Point Measurement” window, generated tie points are displayed as shown below then Visual check of tie points generated automatically must be conducted one by one clicking each row..



9. If a tie point is not observed correctly, it is possible to eliminate it by clicking target cell as shown below (Off Active: Delete Check mark).

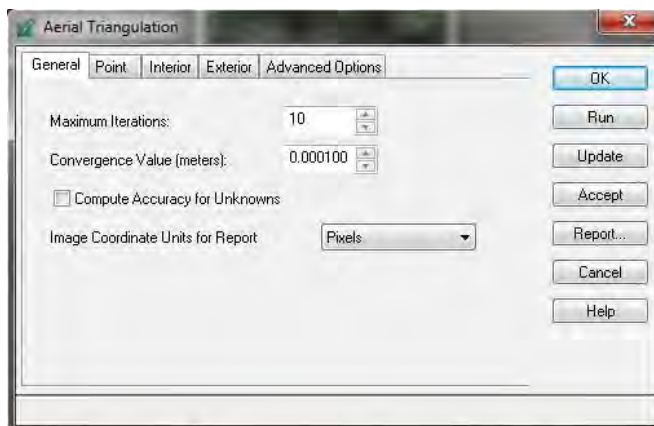


6. Block Adjustment

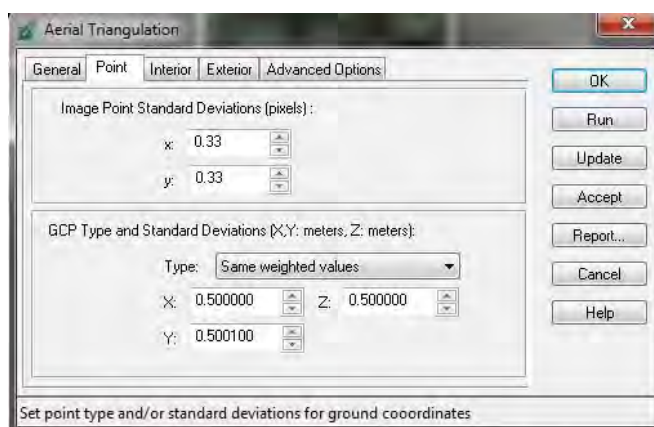
1. Click this icon to set any options for aerial triangulation.



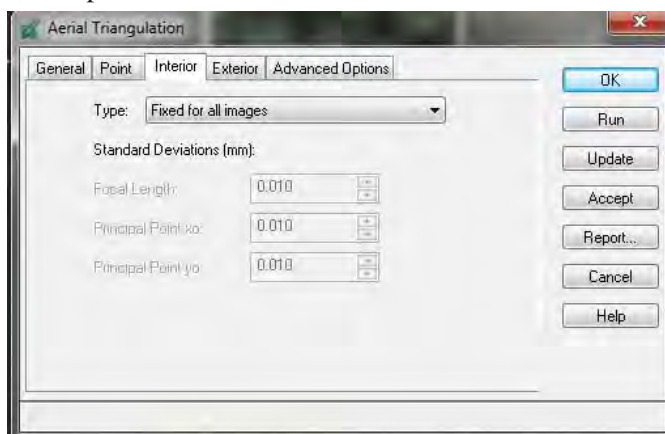
2. The “Aerial Triangulation” window appears. In the “General” tab, set options as shown below. Convergence value shall be “0.0001” in case of large scale map, and “0.01” in case of small scale map.



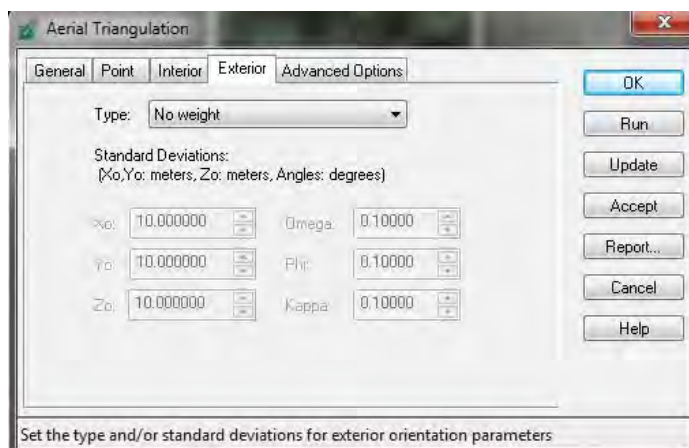
3. In the “point” tab, set options as shown below.



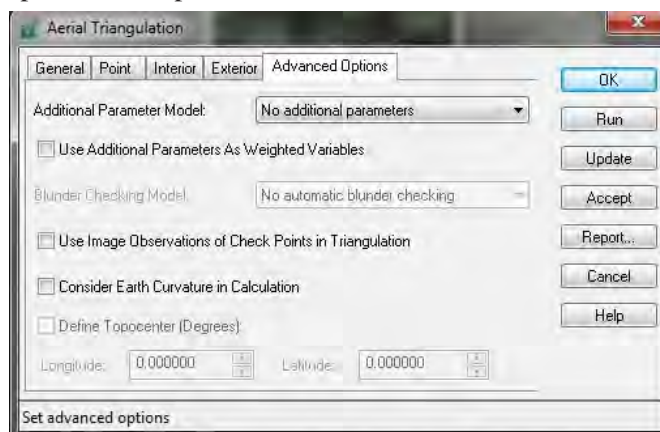
4. In the “Interior” tab, set options as shown below.



5. In the “Exterior” tab, set options as shown below. Normally, standard deviation is not set because exterior orientation parameters are unknown.

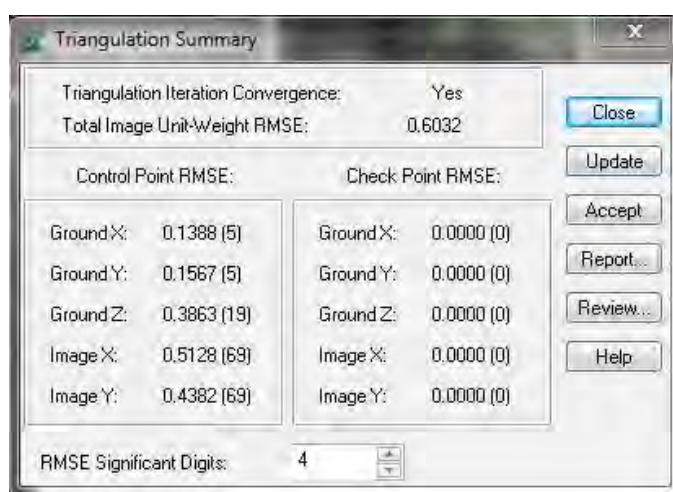


6. In the “Advanced Options”, set options as shown below.



7. After any options are set correctly, click “Run” to execute triangulation.

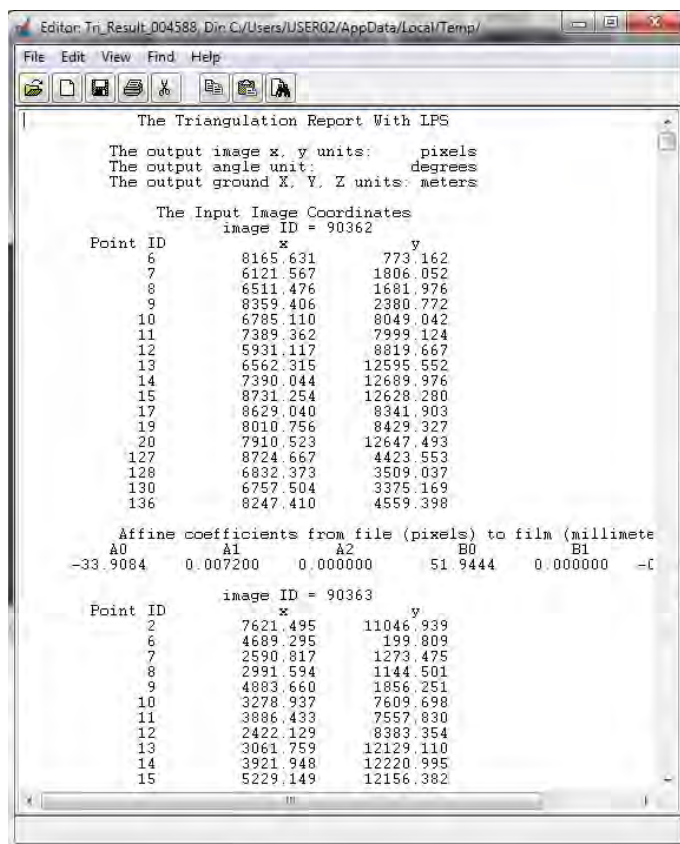
8. After finishing triangulation, the “Triangulation Summary” window appears.



9. If the values are satisfied with the limitation value, click “Accept”.

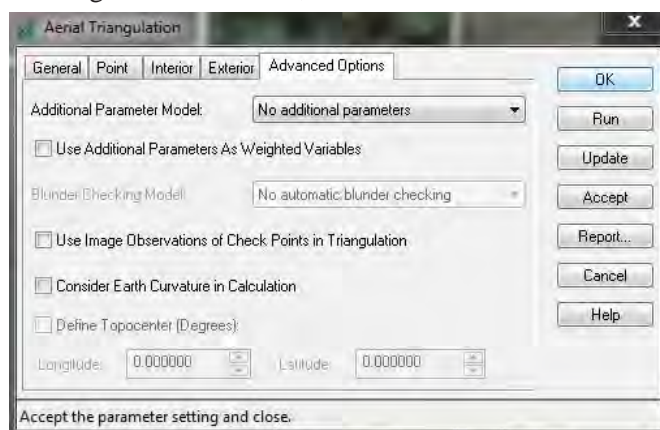
10. By clicking “Report”, the report opens as shown below.

It is strongly recommended to save the report.



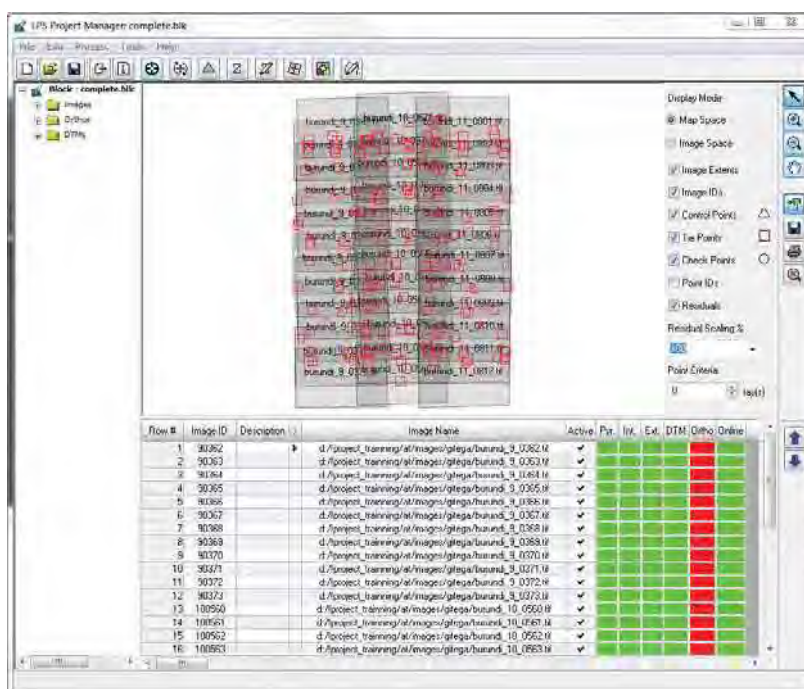
11. To close the “Triangulation Summary” window, click “Close”.

12. To close the “Aerial Triangulation” window, click “OK”.



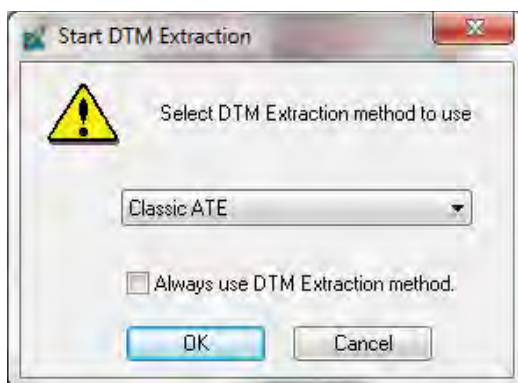
13. To save the result of aerial triangulation, click “Save” and “Close” in the tool palette of the “Point Measurement” window

14. In the “Project Manager” window, column of “Ext” turns to green as show below.



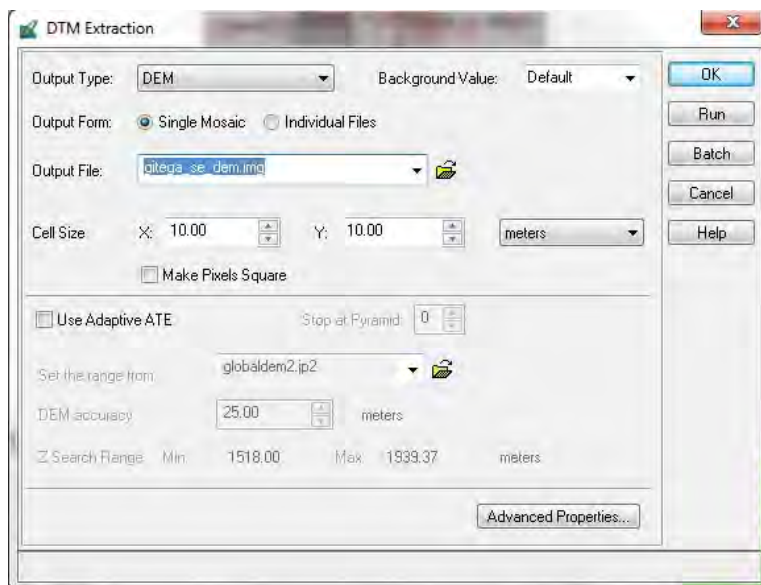
7. DEM extraction

1. Click this icon in the “Project Manager” window to generate DEM then choose "Classic ATE" in the following window.



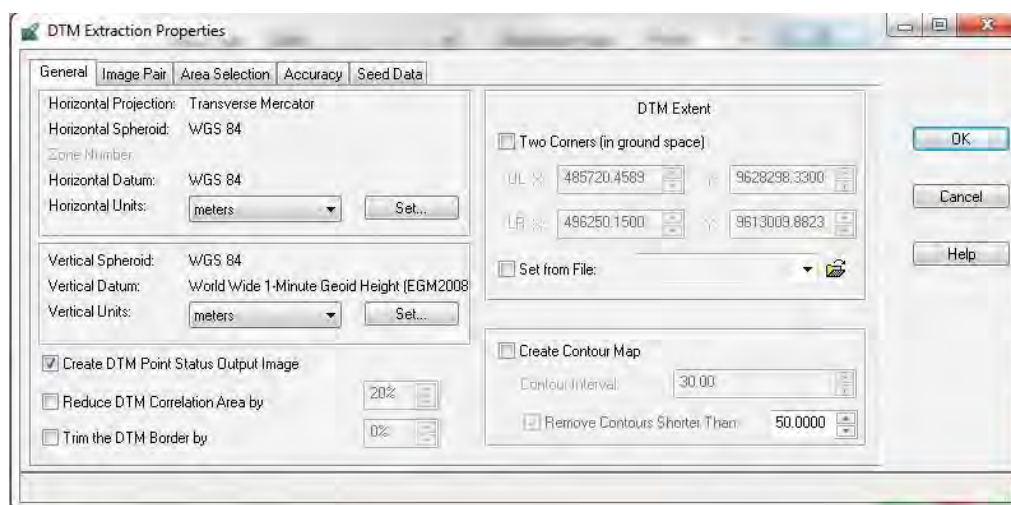
2. The “DTM Extraction” window appears. Set options as shown below. The output file shall be

set in any folder. Generally, cell size should be 3 times bigger than resolution of image.

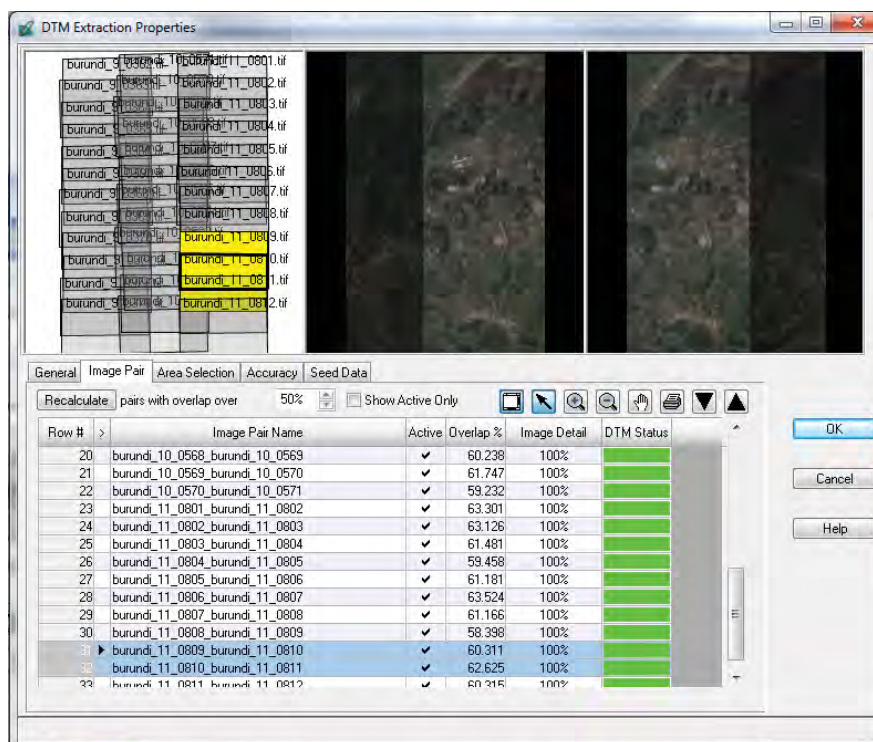
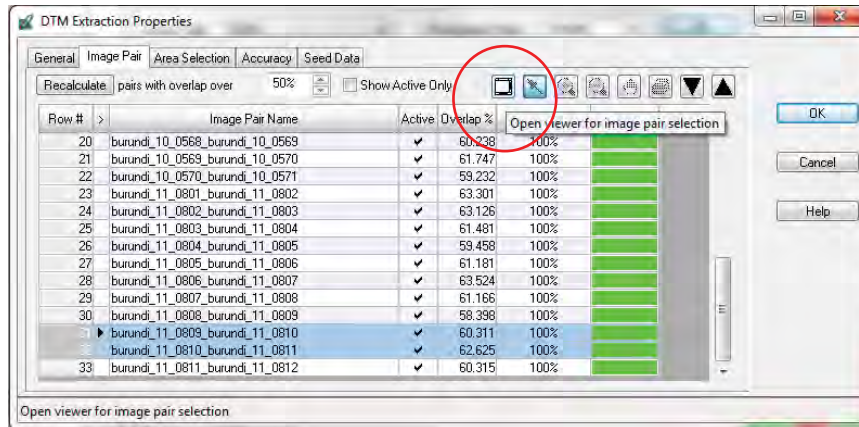


3. Click “Advanced Properties...”.

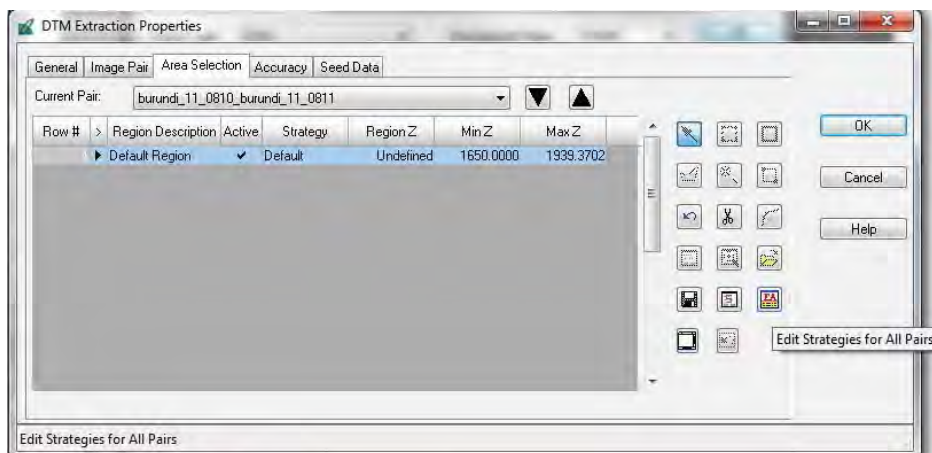
4. The “DTM Extraction Properties” window appears. Select parameters as shown below.



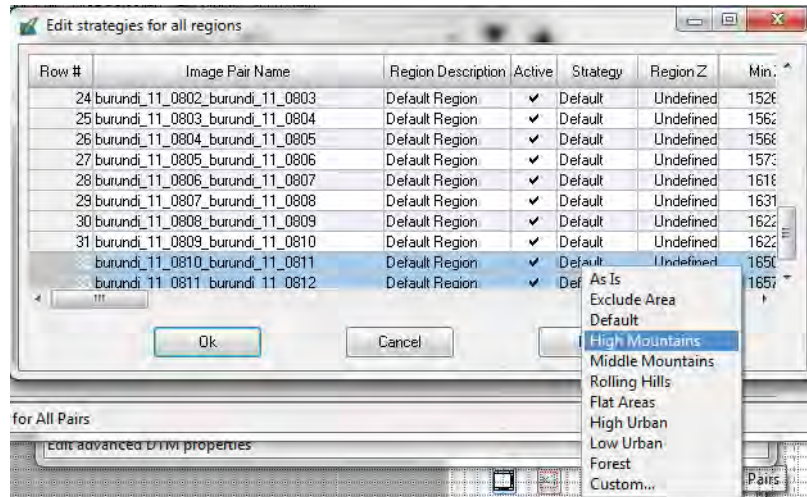
5. By clicking the following icon in the “Image Pair” tab, it is possible to display the view of image pair.



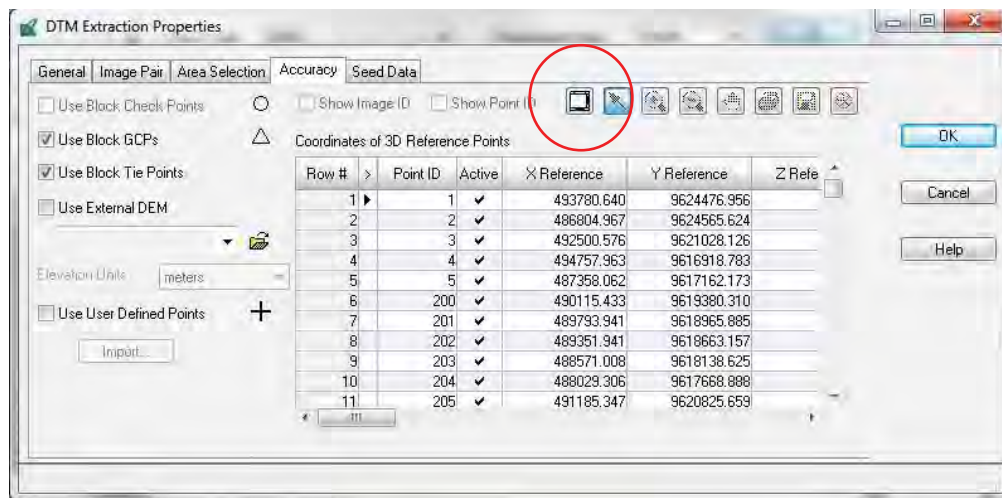
6. In the “Area Selection” tab, click the following icon.



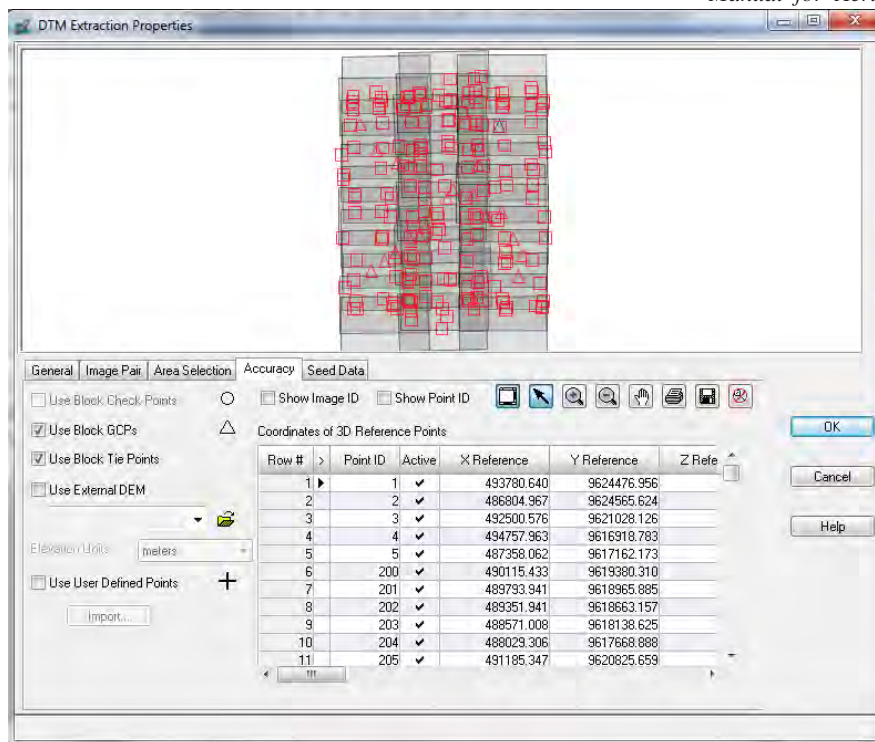
- The “Edit strategies for all regions” window appears. It is possible to set circumstance of target area by clicking column of “Strategy” as shown below. And then click “OK”.



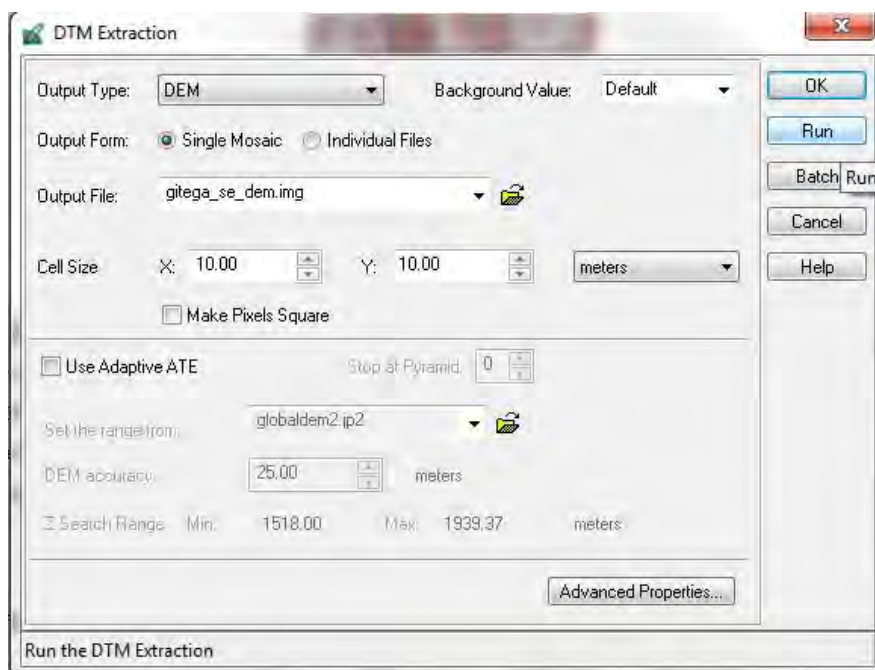
- In the “Accuracy” tab, any options shall be set as shown below.



- By clicking this icon, the view is displayed as shown below. And then click “OK”



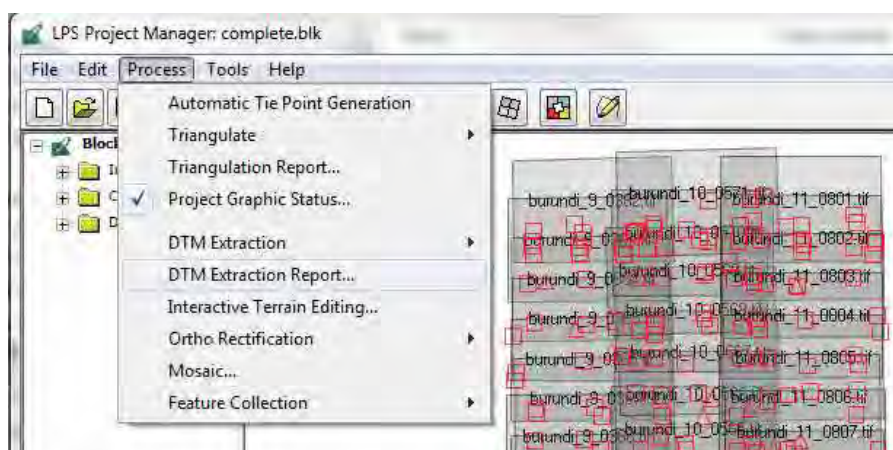
10. In the “DTM Extraction” window, click “Run”.



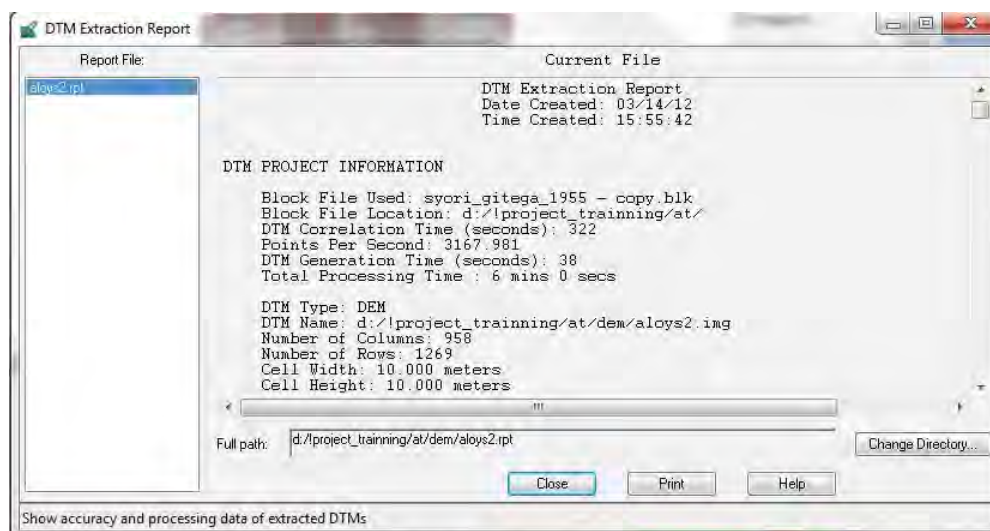
11. After DTM extraction, column of “DTM” turns to green.

Row #	Image ID	Description	Image Name	Active	Pyr.	Int.	Ext.	DTM	Ortho	Online
1	90362		d:/project_training/at/images/gitega/burundi_9_0362.tif	✓	✓	✓	✓	✓	✓	✓
2	90363		d:/project_training/at/images/gitega/burundi_9_0363.tif	✓	✓	✓	✓	✓	✓	✓
3	90364		d:/project_training/at/images/gitega/burundi_9_0364.tif	✓	✓	✓	✓	✓	✓	✓
4	90365		d:/project_training/at/images/gitega/burundi_9_0365.tif	✓	✓	✓	✓	✓	✓	✓
5	90366		d:/project_training/at/images/gitega/burundi_9_0366.tif	✓	✓	✓	✓	✓	✓	✓
6	90367		d:/project_training/at/images/gitega/burundi_9_0367.tif	✓	✓	✓	✓	✓	✓	✓
7	90368		d:/project_training/at/images/gitega/burundi_9_0368.tif	✓	✓	✓	✓	✓	✓	✓
8	90369		d:/project_training/at/images/gitega/burundi_9_0369.tif	✓	✓	✓	✓	✓	✓	✓
9	90370		d:/project_training/at/images/gitega/burundi_9_0370.tif	✓	✓	✓	✓	✓	✓	✓

- To check the result of DTM Extraction, open the report from the menu bar of the “Project Manager” window.



- The report opens as shown below. In the report, the general quality information, general vertical and horizontal information and so on are described.



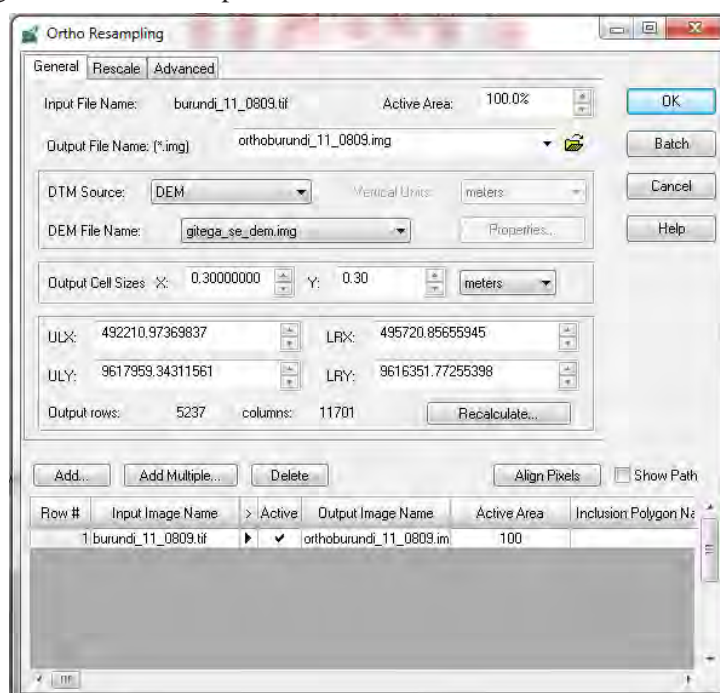
8. Orthorectification

This function is used for the Orthorectification Process one image by one image.

1. Choose a target image and Click this icon to generate ortho image in the “Project Manager” window.



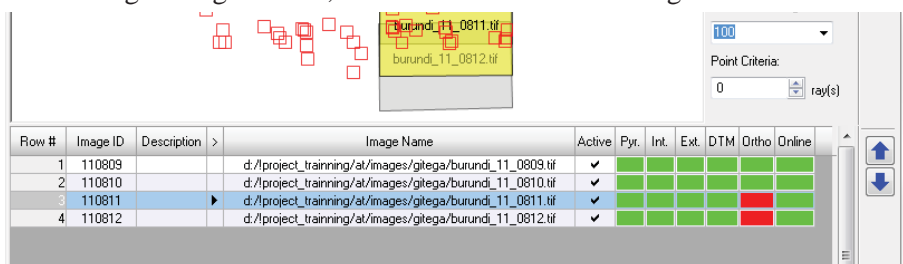
2. The “Ortho Resampling” window appears. In this window, set options as shown below. DEM file which was generated in above process shall be set in this window.



3. In the “Advanced” tab, set options as shown below. And click “OK”.



4. After the ortho image was generated, column of “Ortho” turns to green.



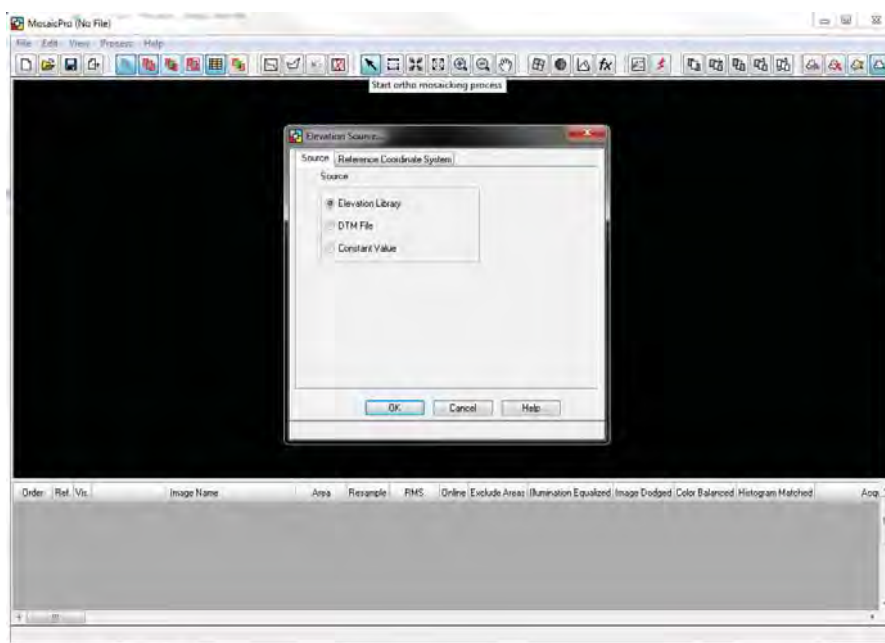
9. Orthorectification and Mosaicking

This function is used for the Mosaicking Process for images orthorectified in previous process.

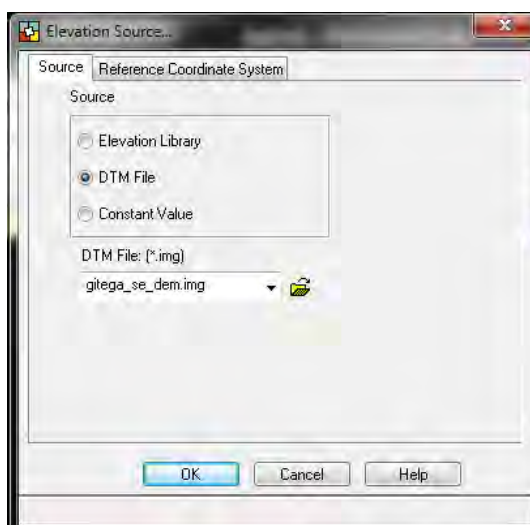
1. Click this icon to execute ortho-mosaicking. Above ortho image generation is for individual image. On the other hand, this ortho-mosaicking can generate ortho images of large area at once.



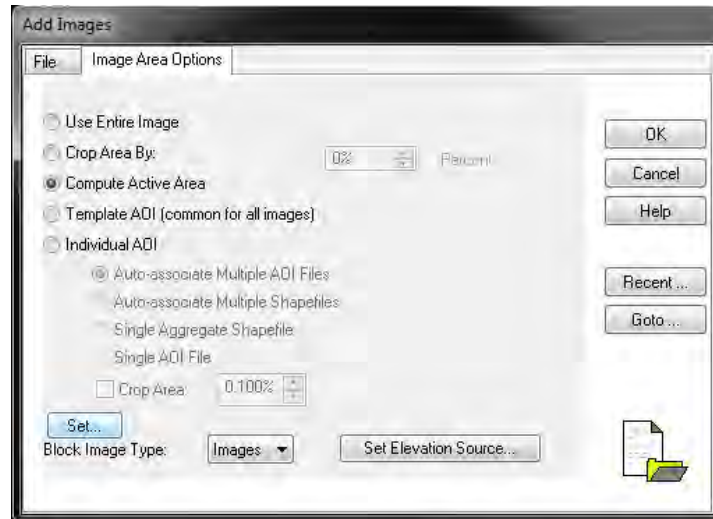
2. The “Mosaic Tool” window appears.



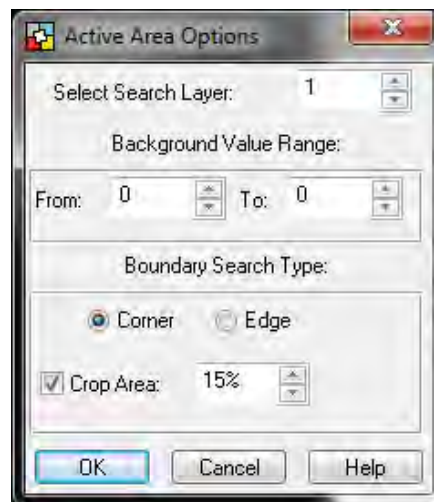
3. In the “Elevation Source...” window, select “DTM File” and set appropriate DTM file. And then click “OK”.



4. The “Add Images” window appears. In the “Image Area Options” tab, select “Compute Active Area” and click “Set...”.



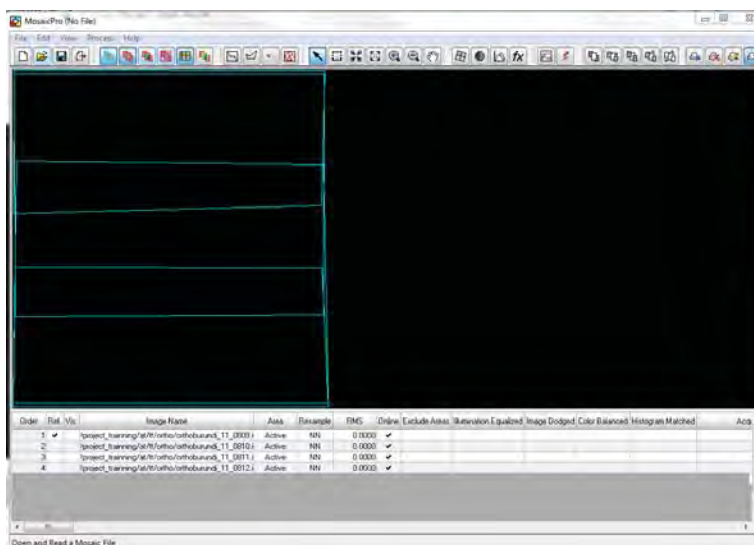
5. In the “Active Area Options” window, set options as shown below. And click “OK”.



6. In the “Add Images” window, click “OK”.

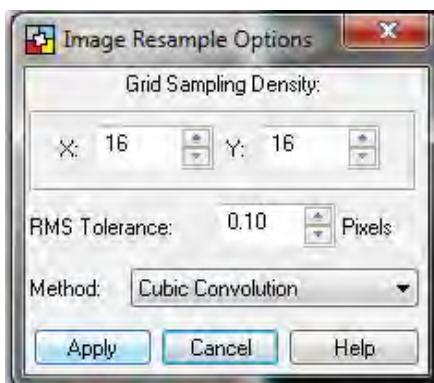


7. In the “Mosaic Tool” window, footprint of image shall be displayed as shown below.



8. Click this icon. Set options as shown below in the “Image Resample Options” window and click “Apply”.





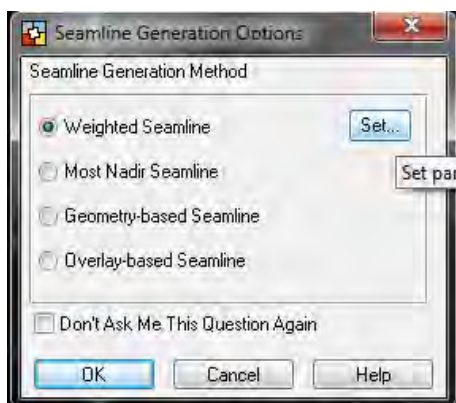
9. Click this icon. Select options as shown below in the “Color Corrections” window and click “OK”.



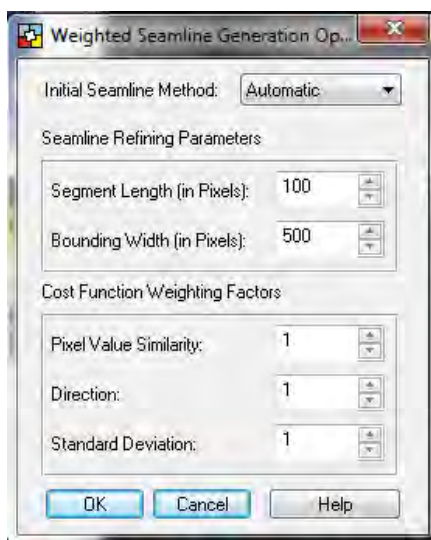
10. Click this icon for setting of automatic outline.



11. In “Cutline Generation Options” window, select “Weighted Cutline” and click “Set...”.



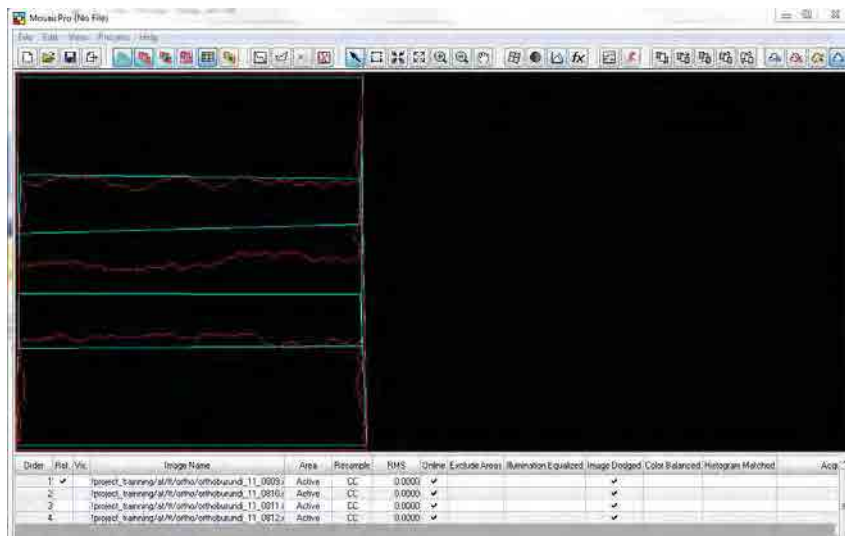
12. In the “Weighted Cutline Generation ...” window, set parameters as shown below and click “OK”.



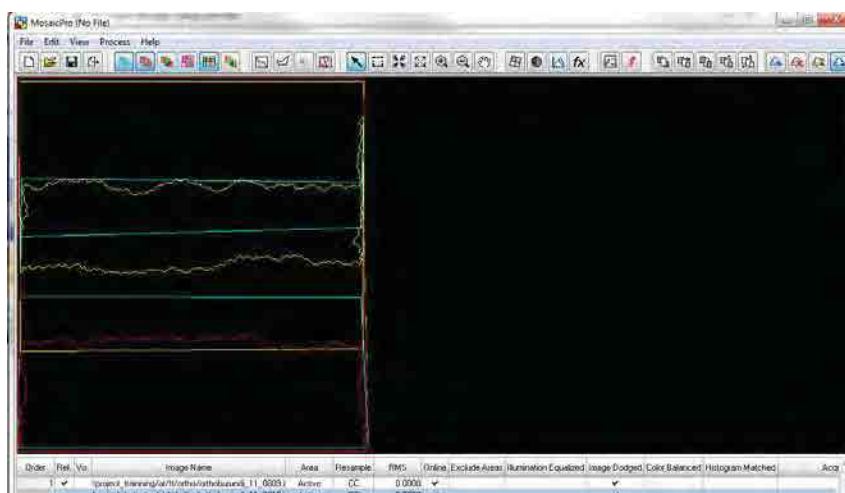
13. In the “Cutline Generation Options” window, click “OK” and close this window.



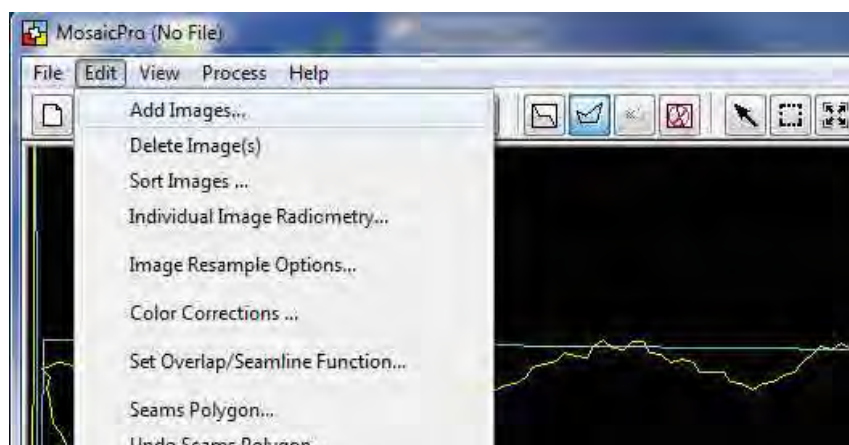
14. The Cutlines are generated automatically and displayed as shown below.



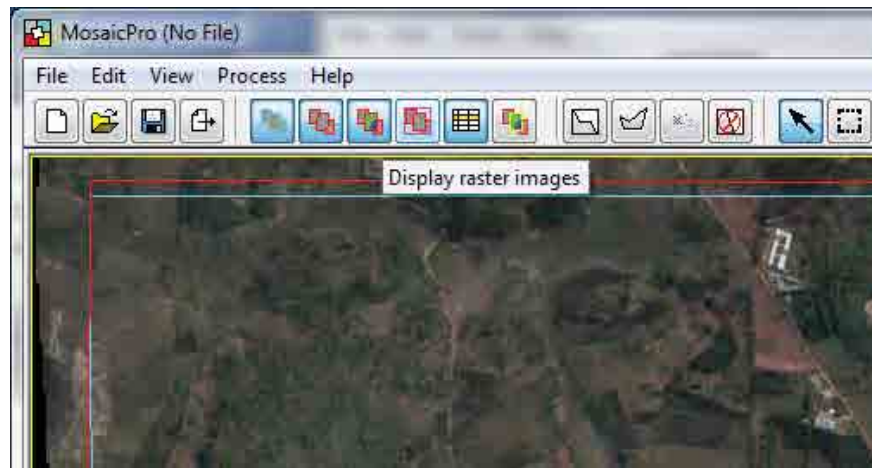
15. In the “Mosaic Tool” window, select overlapped area (frame turns to yellow) and click the following icon.



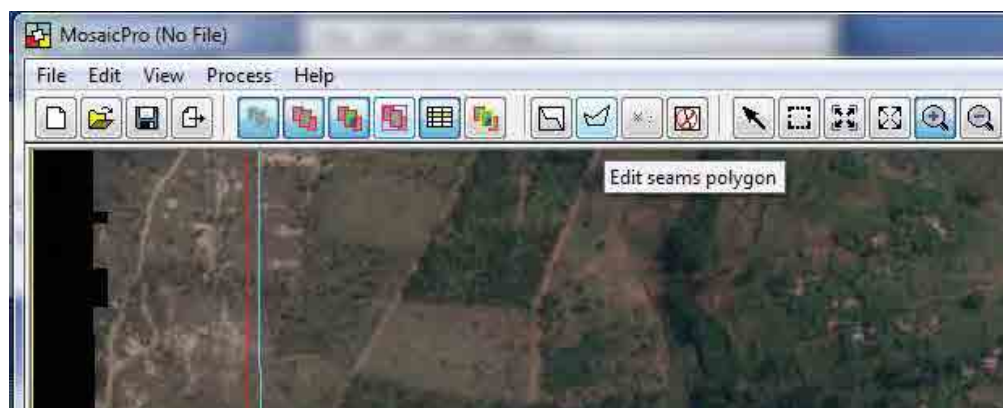
16. In case to check Seamlines, import target image.



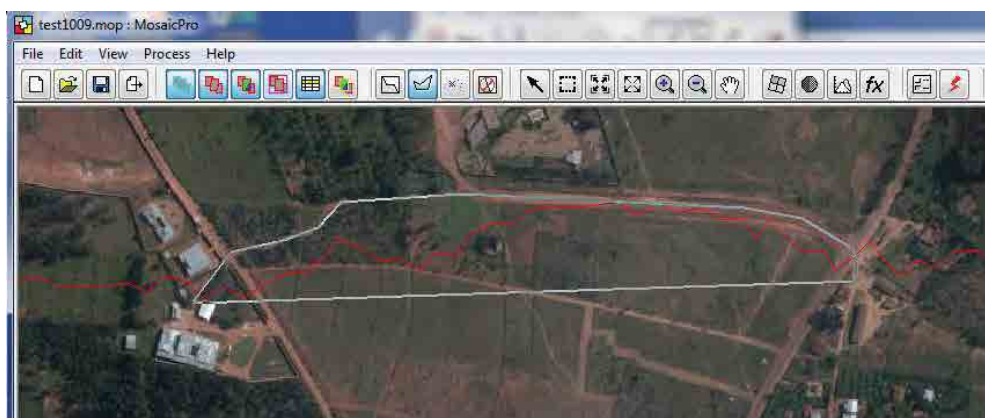
Click on "Display raster images" icon.



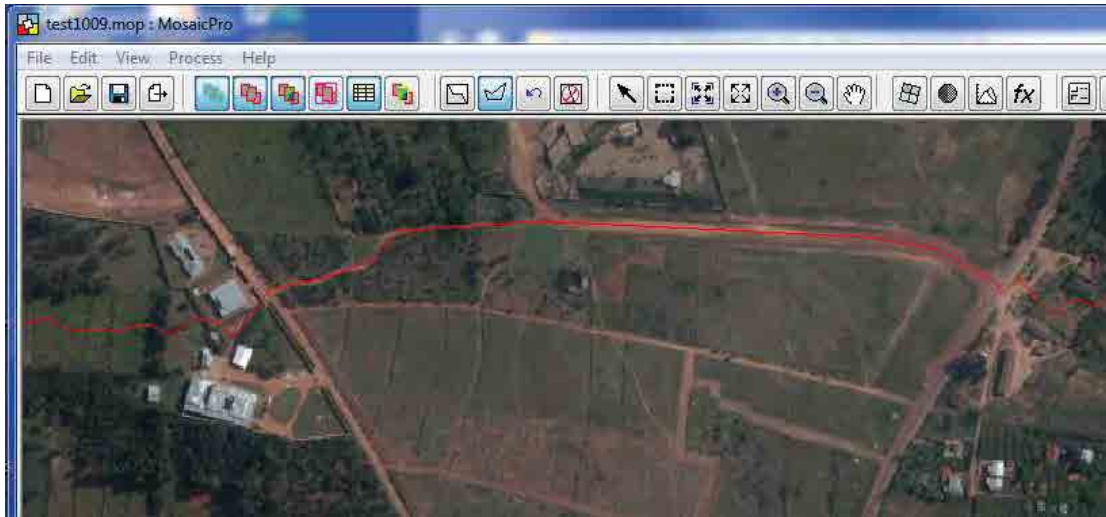
Click on "Edit seams polygon " icon.



17. Draw appropriate line by "Lmb" then "double click" on the end point.



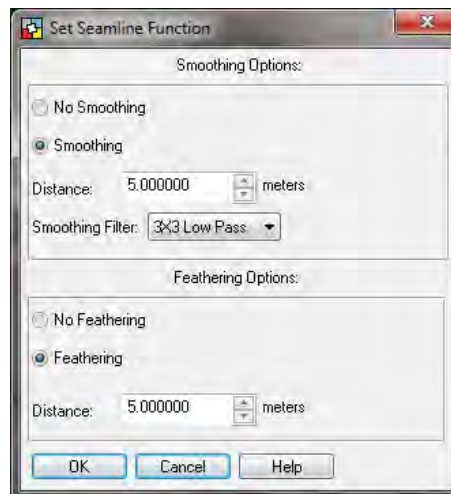
18. Seam line was modified.



19. Click this icon.



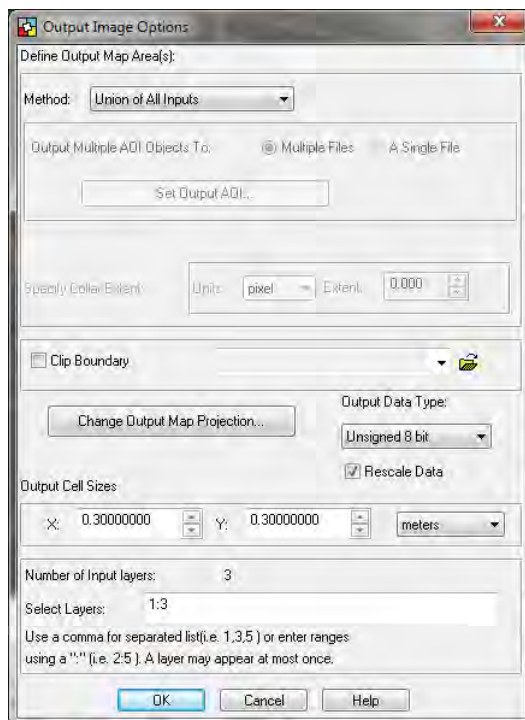
20. In the “Set Overlap Function” window, select options and set parameters as shown below. And click “OK” then click “Close”.



21. Click this icon in “Mosaic Tool” window.



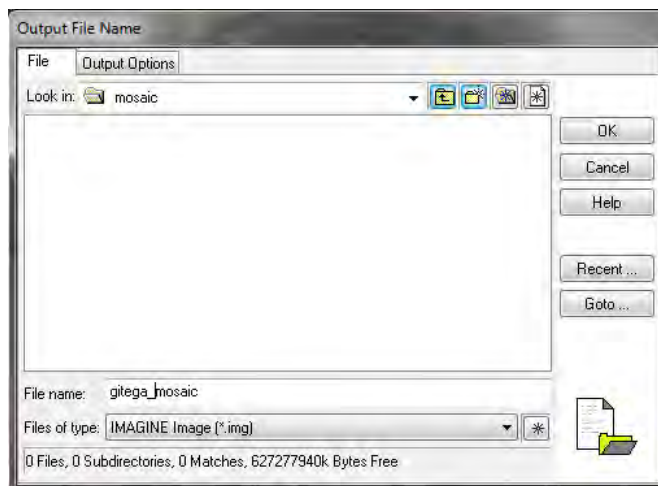
22. In the “Output Image Options” window, select options and set parameters as shown below. And click “OK”.



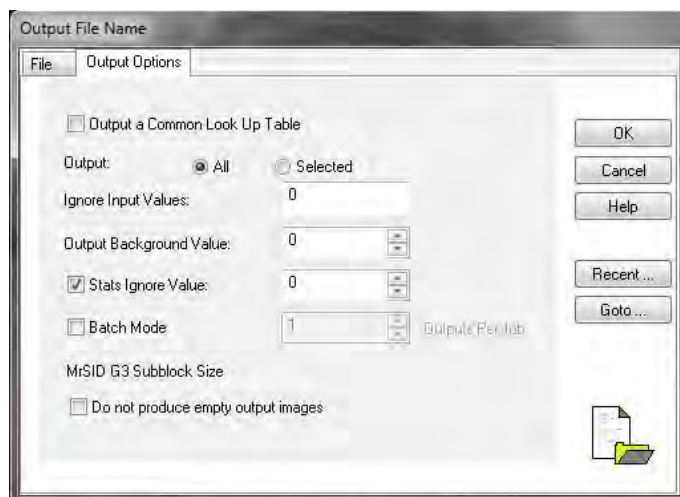
23. Click this icon to execute mosaicking in the “Mosaic Tool” window.



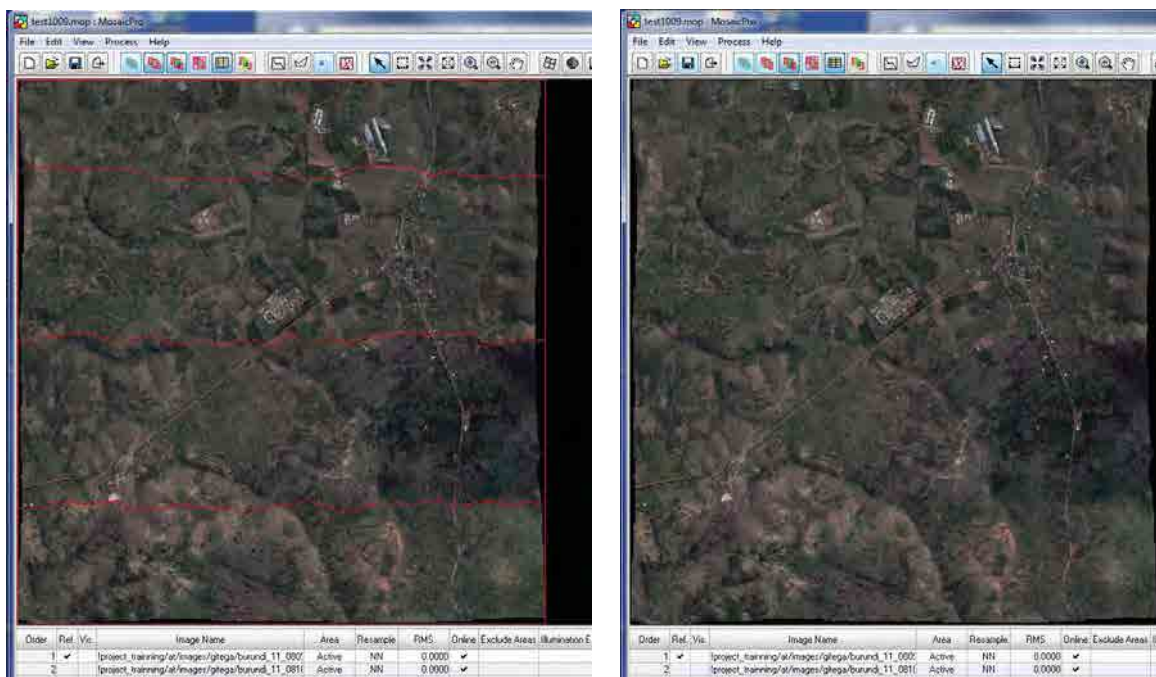
24. In the “Output File Name” window, type output file name.



25. In the “Output Options” tab, set parameters as shown below and click “OK”.



26. Ortho mosaicked image are generated as shown below.



Note: For further information of LPS, see the manuals by Leica in the following address.
 Installation drive\Program Files\Leica Geosystems

Digital Plotting

The Basic Theory of Digital Plotting

<Objective>

Acquire the data of geographic features on stereo viewing by using DPW (Digital Photogrammetric Workstation).

1. Planning

Planning map that the work area, map quadrangle and principal points of aerial photos are drawn shall be prepared. And the time schedule shall be created under consideration of necessary date, assignment of operators, data checking system and so on.

The following items shall be considered during planning.

- A) Experience of operators (In case operators have many experiences, quality of data shall be higher and operating time shall be faster)
- B) Density of settlements and roads in work area (It takes time for data acquisition in urban area than rural area)
- C) Terrain circumstance of work area (It is necessary to acquire a lot of contour data on mountainous area)
- D) Mapping scale (The way of data acquisition differ depending on the scale)

2. Preparation

2.1 Required equipments, documents and data for this work are followings.

- A) Work planning map
- B) Image data which were covered work area (the data format shall depend on software used)
- C) The result of aerial triangulation (coordinate of path-points and tie-points, exterior orientation parameter)
- D) Calibration report of camera which was used for aerial photography (**value of focal length, coordinate of fiducial marks and lens distortion**)
- E) The result of field identification
- F) The specification of data acquisition and map symbols
- G) DPW (Digital Photogrammetric Workstation)
- H) Library data for lines and symbols (for symbolization of plotting data)
- I) Various documents (for control points, pipe lines, power lines and so on)

Notice : Above items which are mentioned on B), C) and D) shall be imported into DPW and stereo models shall be established. In addition, if the existing data such as a list of control points have already obtained, they shall be imported into DPW and plotted.

3. Digital Plotting

Data of geographic features, vegetation and terrain which are expressed onto topographic map shall be acquired in accordance with the specification of data acquisition during photo interpretation. Additionally, if field identification was carried out, the result shall be referred during plotting.

3.1 The order of data acquisition.

Data acquisition generally shall be conducted along the following order.

- 1). Line data which shall be bones. (road, railway, river, canal, lake, shore line, power line, pipe line and so on)
- 2). Data of buildings, small objects, land marks and plottage. (various buildings, fences, revetments, wells, various tanks, transformer stations, various towers, cemeteries and so on)
- 3). Vegetation data (rice field, crop field, orchard, various plantation, forest, bush and so on)
- 4). Terrain data (contour, cliff, spot height and so on)

3.2 Points to notice during digital plotting

- 1). Operator has to appreciate the contents of the specification of data acquisition and map symbols. When items which not listed in the specification are found, it is necessary to report to manager and receive proper indications from manager.
- 2). Road, river, pipe line, power line, contour and so on excluding supplementary contour should be continuous as a general rule.
- 3). When field identification was carried out, data acquisition has to be carried out according to the result. If there are some doubts in the result, they shall be marked and verified in field completion.
- 4). When the data are acquired by photo interpretation, the shapes of objects, color tone of objects, pattern of objects, shadow, height of objects, and characteristic in work area shall be considered. If it is impossible to identify any objects, they shall be verified in field completion.
- 5). In the case of road data, the order of data acquisition shall be from high order such as 1) national road, 2) local road, 3) cart truck, 4) footpath. If cart trucks and footpaths exist adjacently, they shall be acquired in a balanced manner depending on the scale.
- 6). In the case of the data which should be duplicate with other data such as bridge for road and bridge of railway, it should be duplicated accurately.
- 7). In the case of acquiring the data such as limit of vegetation, it should be started from / reached to on the line data such as road and river data. And there should be no any dongle error.
- 8). In the case of polygon data such as buildings, limit of vegetation and so on, start point and end point must be duplicated.
- 9). In the case of acquiring building data as actual shape, neighboring buildings must be not crossed. (especially, it is necessary to pay attention in urban area)
- 10). In the case of acquiring vegetation data, a symbol shall be located in an area.

- 11). Contour data must not intersect (especially it is necessary to pay attention in the steep area such as cliff.
- 12). Contour data of top of mountains, hills and depression is apt to be neglected. To avoid it, acquiring spot height on the top of them is effective way.
- 13). In the case of acquiring contour data of the plain, operator shall not only concentrate of cursor condition but also consider circum-terrain.
- 14). After completing digital plotting, leakage of data shall be checked on the stereo model.
- 15). When operator carry out plotting on next stereo model or next map sheet, operator must pay attention about leakage and connectivity of data.
- 16). In the case of generating of contour data from DEM, it must be checked on 3D and defect data must be edited in comparison to terrain condition.

4. Photo Interpretation

Geographic features which came out on the photos shall be interpreted by their shapes, color patterns, shadows, height and so on. Generally, the accuracy of interpretation is higher skilled person than beginner, color image than monochrome image, large scaled photo than small scaled photo, 3D than 2D. Besides, the accuracy of interpretation will be higher if operator is familiar with characteristic of work area such as industry, weather, and religion. Generally, small objects and low height features shall be difficult to interpret.

On monochrome images, water area and wet land shall be seen dark, dry area shall be seen lightly, conifer forest shall be seen more dark than broad leaf forest.

Examples of photo interpretation (In the case of using monochrome images)

Features	Conditions
Mosques	Minarets are identified on the buildings. And there is dome on the roof.
Factories	Chimneys and plants are identified with large buildings. But, small factories, factories without chimneys and plants are difficult to interpret.
Thermal power station	A number of large chimneys and buildings are identified in the plottage that is surrounded with walls and fences. Additionally, substation facilities exist nearby and a number of power lines shall be identified.
Hydroelectric power station	A linear object which headed straight for large river shall be identified (It shall be a dam). Artificial lake shall be seen on upstream of a dam. Large buildings that are surrounded with walls and fences shall be seen on downstream of a dam. Additionally, substation facilities exist nearby and a number of power lines shall be identified.
Airport	Air strips, taxiways, aprons shall be identified in vast plottage that is surrounded with walls and fences. Besides, large buildings and hangars shall be identified. A number of airplanes shall be identified on aprons.

Road	Whitish continued linear which are composed of straight and curve shall be seen. Footpaths are often slightly difficult to identify because they are often not continuously.
Rail way	This is as well as road. However, this is more linear shape and has a large curvature in comparison to road.
Forest	Dense elevated woods shall be identified and surface of the ground shall be difficult to see. Conifer forest looks dark and textured on the photo because the tree canopy is sharp. Moreover, limit of conifer forest shall be rectilinear because it is often planted. Broad leaf forest looks slightly dark and smooth compared with conifer forest because the tree canopy is wide.
Cropland	Zoning by whitish linear objects such as road and blackish linear objects such as canal. In case crop is not cultivated, although this looks whitish as with bare land, this shall be identified by existence or nonexistence of zoning. After cultivation, this looks blackish as with grassland. Grassland looks smooth, meanwhile this is regularly-cultivated, so that this looks textured and ridges might be identified in good condition.
Orchard	Timber is regularly-located and this limit is rectilinear, so that this shall be identified easily.
Tower	Large towers shall be identified easily in large scaled aerial photo. Meanwhile, small towers and large towers in small scaled aerial photo are difficult to identify but it is possible to identify this by finding its shadow.

5. Schedule Control

Manager must appreciate the progress situation on the day before weekend. If the progress is delayed, discussion of countermeasure and readjustment of schedule shall be needed. Moreover, in case lengthy delays are expected, manager might increase the number of operators and make a two-shift system to complete the work within period.

6. Quality Control-1

After completing of digital plotting, the data shall be printed out on the same scale with deliverable and on a size of a map quadrangle. At that time, the data shall be divided planimetric features from terrain features and be printed out. And balance of map data, mistakes of the data acquisition, leakage of data acquisition, existence or nonexistence of dangle gaps and so on shall be checked. Checked place shall be marked and lead line shall be drawn with instruction for editing on the map printed out.

If it is possible to use checking tools of GIS software for error searching and editing, the functions shall be useful and efficient.

6.1 Checking of planimetric data

- 1). Mistakes of code number of data
- 2). Leakage of data acquisition (ortho image shall be used for background if there are no photos of field identification)
- 3). Leakage of inputting the result of field identification
- 4). Balance of data acquisition for cart tracks and footpaths
- 5). Intersecting of building data which is acquired as actual shape.
- 6). Duplicating of the data on a same line.
- 7). Existence or nonexistence of road data which is shorter than defined length in the specification.
- 8). Existence or nonexistence of river data which is shorter than defined length in the specification.
- 9). Existence or nonexistence of vegetation data which is smaller than defined size in the specification.
- 10). Existence or nonexistence of unknown area by leakage of vegetation symbol.
- 11). Existence or nonexistence of dangles and gaps.

6.2 Checking of terrain data

- 1). Mistakes of code number of data.
- 2). Leakage of data acquisition
- 3). Elevation value of contour data (existence or nonexistence of broken number)
- 4). The number of principal contours between index contours
- 5). Intersecting of contour data
- 6). Condition of data acquisition of supplementary contour
- 7). Consistency of elevation value among contour, spot heights and control points
- 8). Balance of data acquisition of spot heights
- 9). Existence or nonexistence of dangles and gaps

7. Revision Plotting

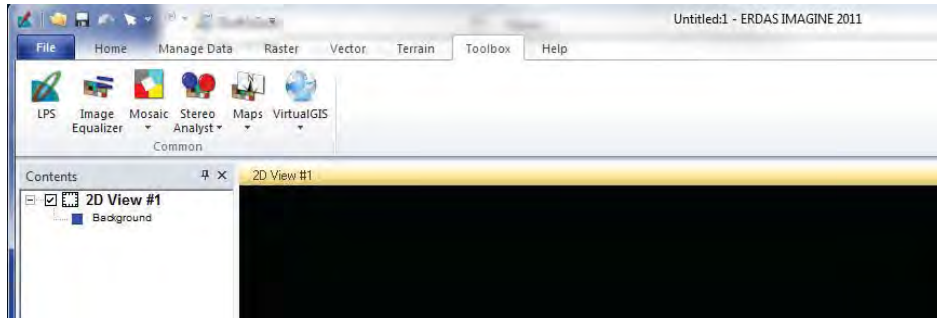
Digital plotting shall be conducted again to modify errors when errors are founded in <Quality control -1>.

8. Quality Control-2

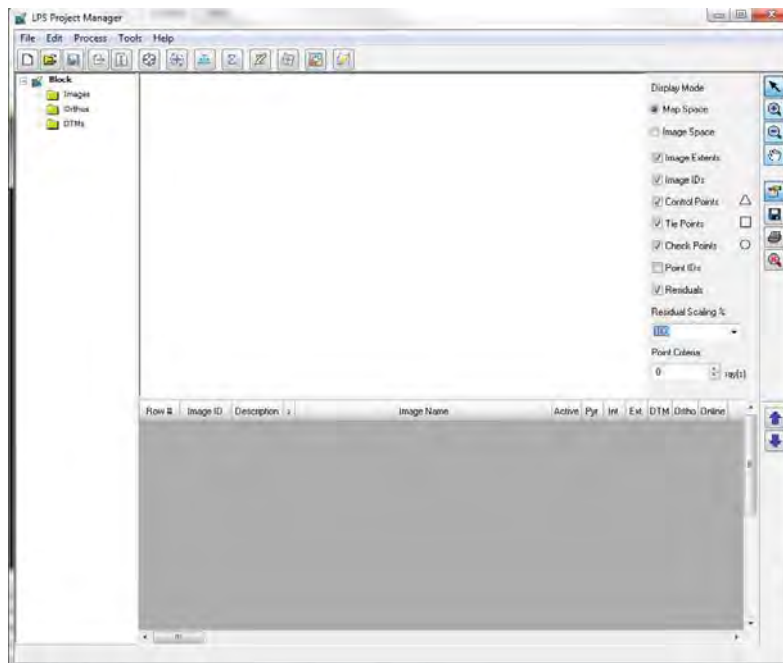
After completing above-mentioned revision plotting, modified items shall be checked again. If there are still errors, revision plotting and checking shall be repeated until there is no any error.

1. Create a project file

- (1). To launch the LPS, double click this icon or select Leica photogrammetry Suite from the Windows program



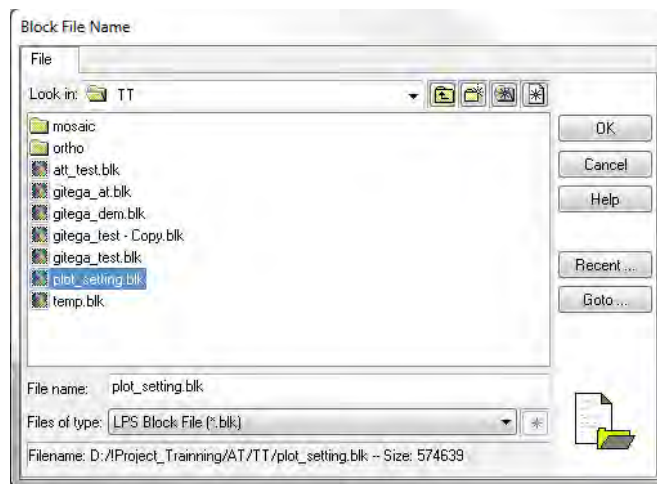
- (2). The “Project Manager” window appears.



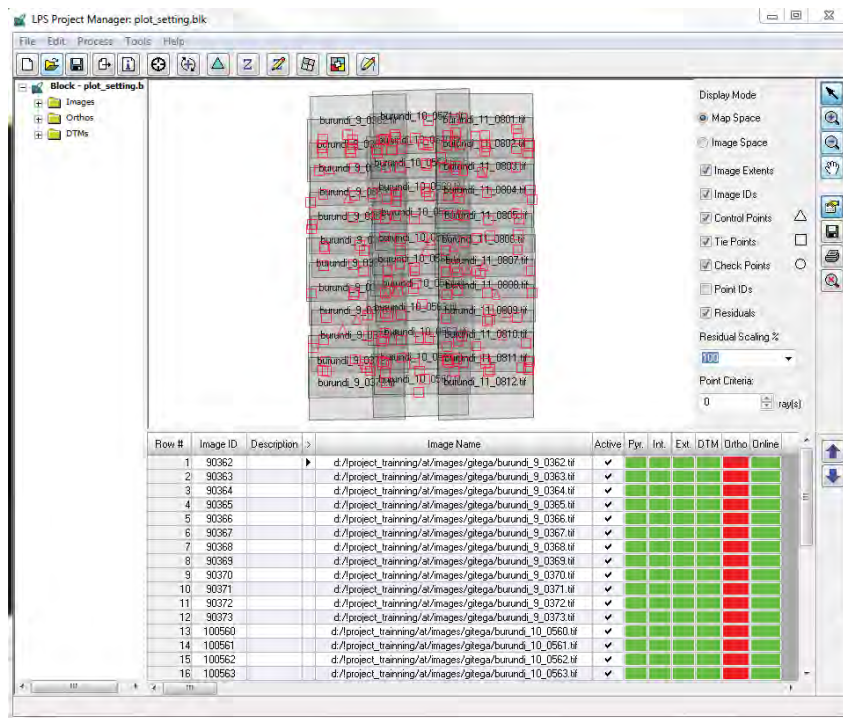
- (3). To open a block file (*.blk), click the following icon.



- (4). Select the appropriate block file which completed aerial triangulation and click “OK”



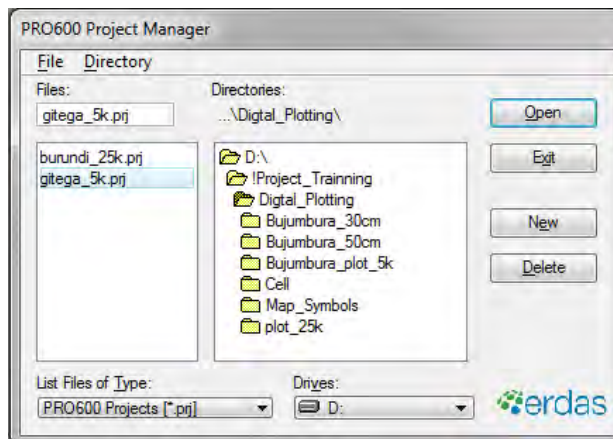
- (5). The footprints of aerial photos are displayed. And check column of 'Pyr', 'Int', 'Ext' and 'Online'. These 3 columns should be filled with green color in order to conduct digital plotting.



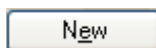
- (6). To start digital plotting, click this icon. And launch “Pro600” software.



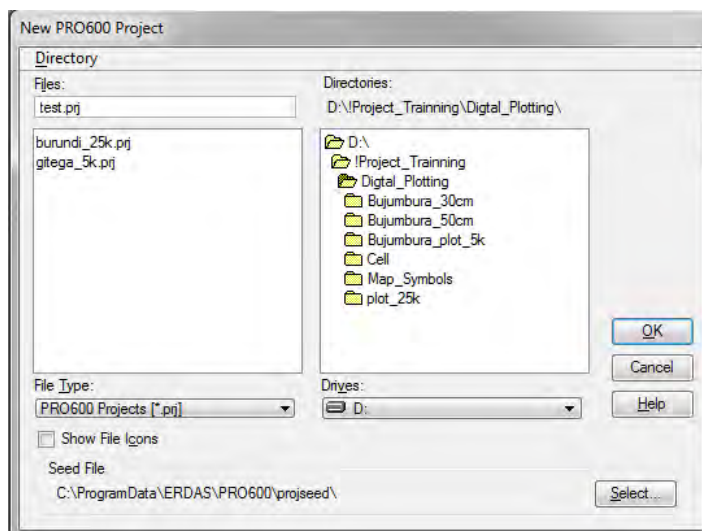
- (7). The “PRO600 Project Manager” appears. If a project file for PRO600 has already made, select appropriate one.



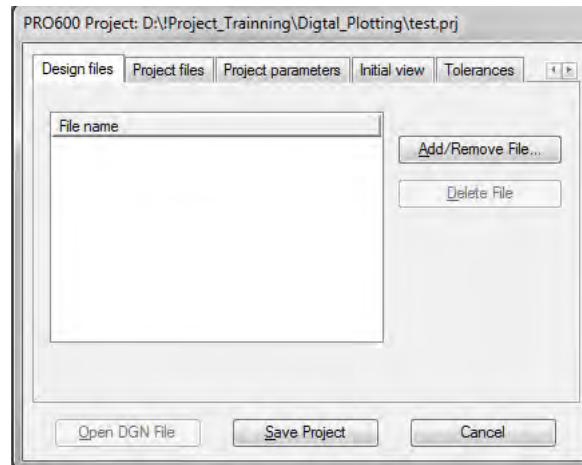
- (8). If a project file for PRO600 has not made yet, click “New” in the “PRO600 Project Manager” window.



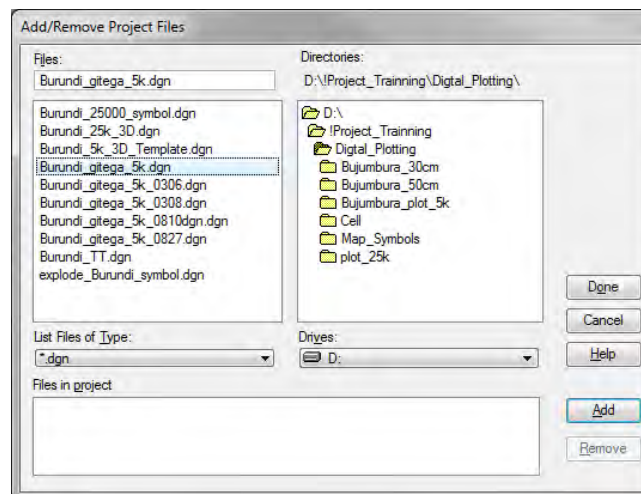
- (9). Type a new project file name in “New PRO600 Project” window. And click “OK”.



- (10). After click “OK”, the “PRO600 Project” window appears. Click “Add/Remove Files...” to add MicroStation design files (*.dgn) on the “Design files” tab. These files shall be created in advance and contain all of necessary layers.

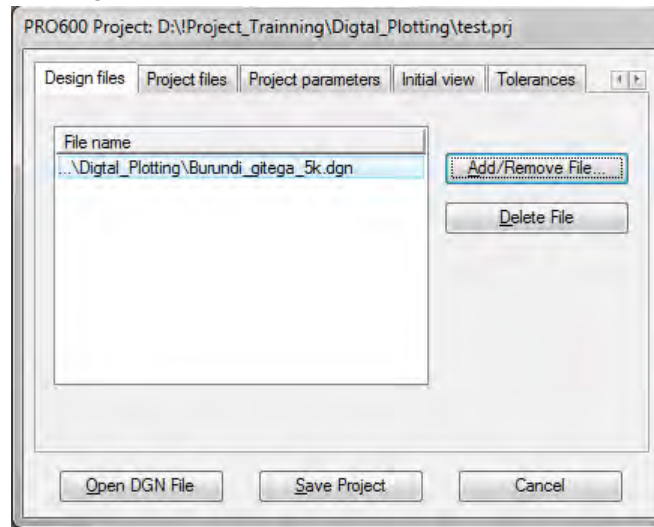


- (11). Select MicroStation design files which were prepared in advance. And click “Add”.

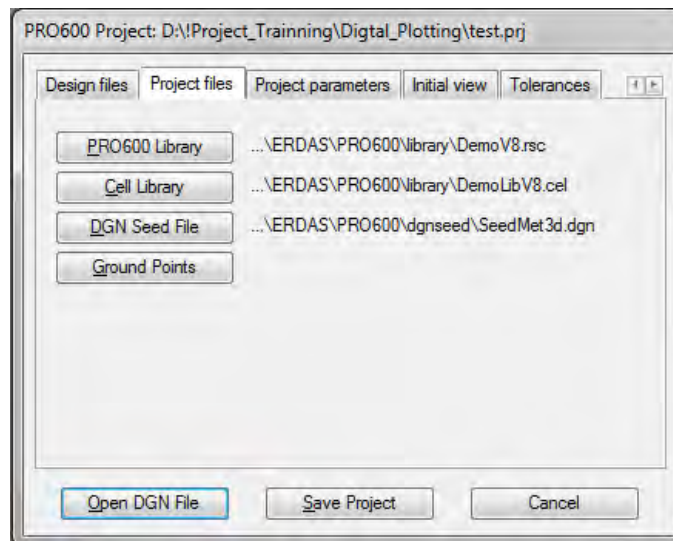


- (12). Click “Add”, and then click “Done”.

- (13). MicroStation design file selected are listed as shown below.

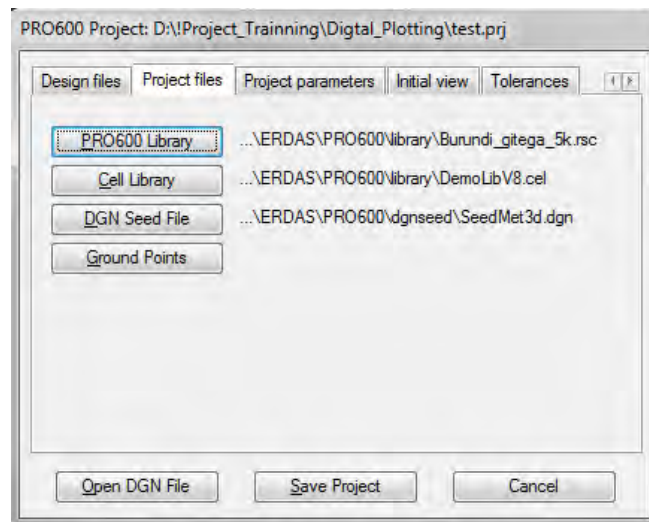
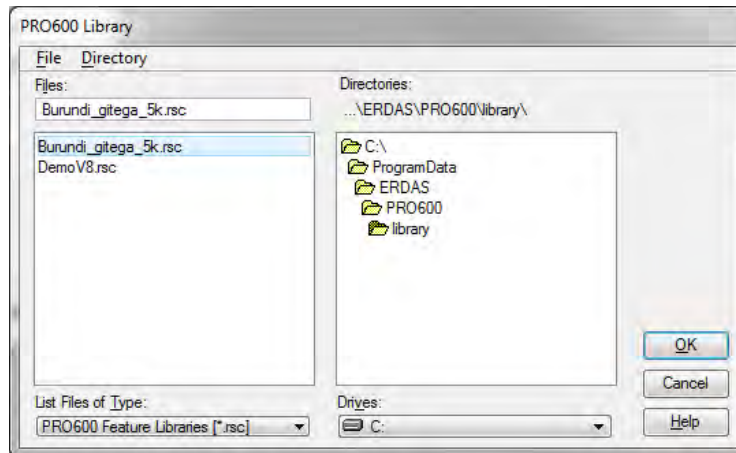


- (14). Go to the "Project files" tab in the "PRO600 Project" window.

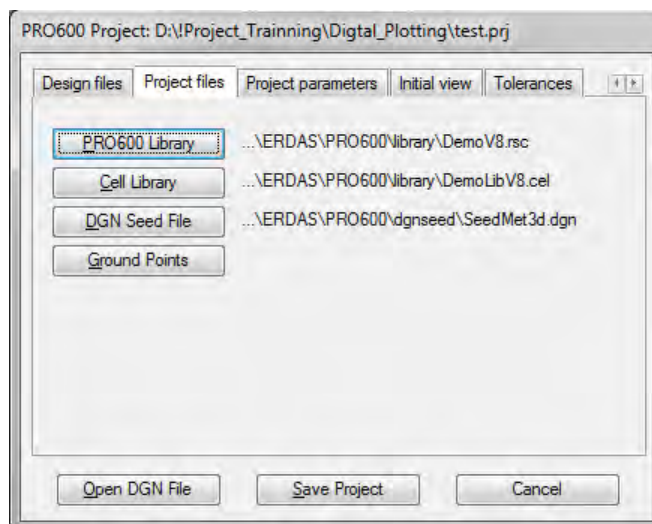


- (15). If a PRO600 Library (*.rsc) file of the project has already prepared, it can be selected here as shown below.

PRO600 Library



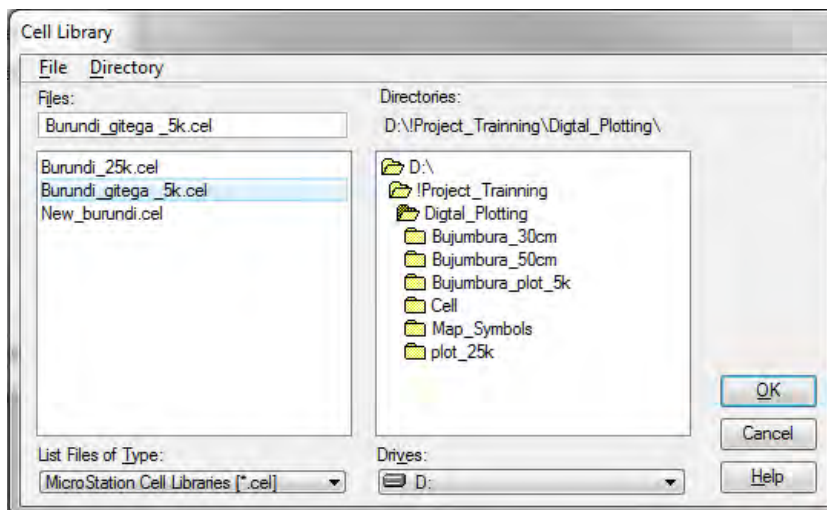
- (16). If a PRO600 Library (*.rsc) file of the project has not prepared yet, default setting is adopted here as shown below.



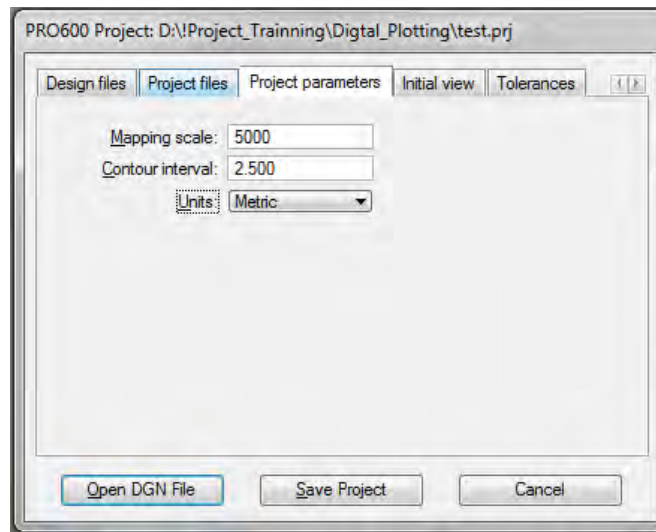
- (17). Click “Cell Library” to select a cell library file (*.cel). A cell library file for the project must be prepared in advance.



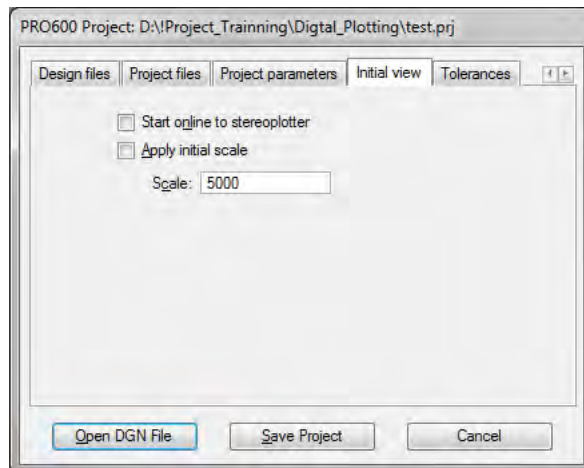
- (18). After selecting a cell library file prepared in advance, click “OK”.



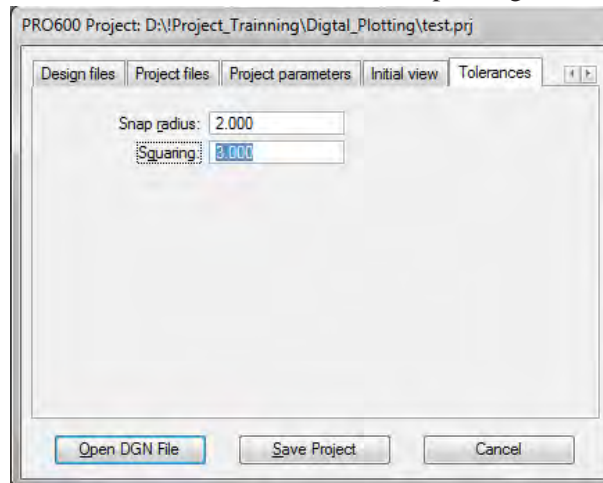
- (19). Go to the “Project parameters” tab in “PRO600 Project” window. And input "Mapping scale" and "Contour interval" as follow as plotting specification.



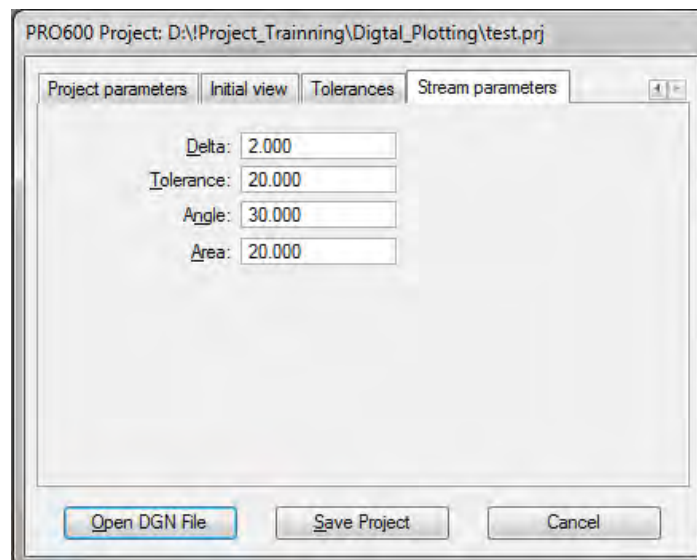
- (20). Go to the “Initial view” tab in the “PRO600 Project” window. Set a parameter as shown below.



- (21). Go to the “Tolerances” tab in the “PRO600 Project” window. And input the values as shown below. Although values are input here as shown below, they can be changed afterword if values are not satisfied with condition of plotting work.

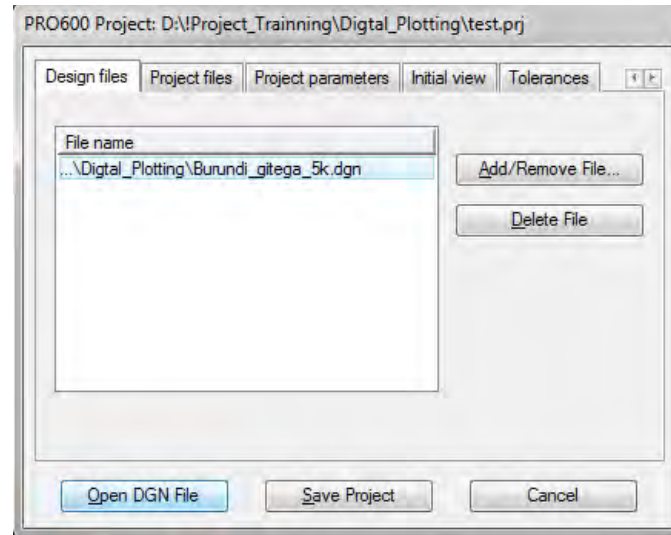


- (22). Go to the “Stream parameters” tab in the “PRO600 Project” window. Values of stream parameters affect smoothness of counter data during plotting. Although values are input here as shown below, they can be changed afterword such as the following second image if the values are not satisfied with smoothness of counter data.



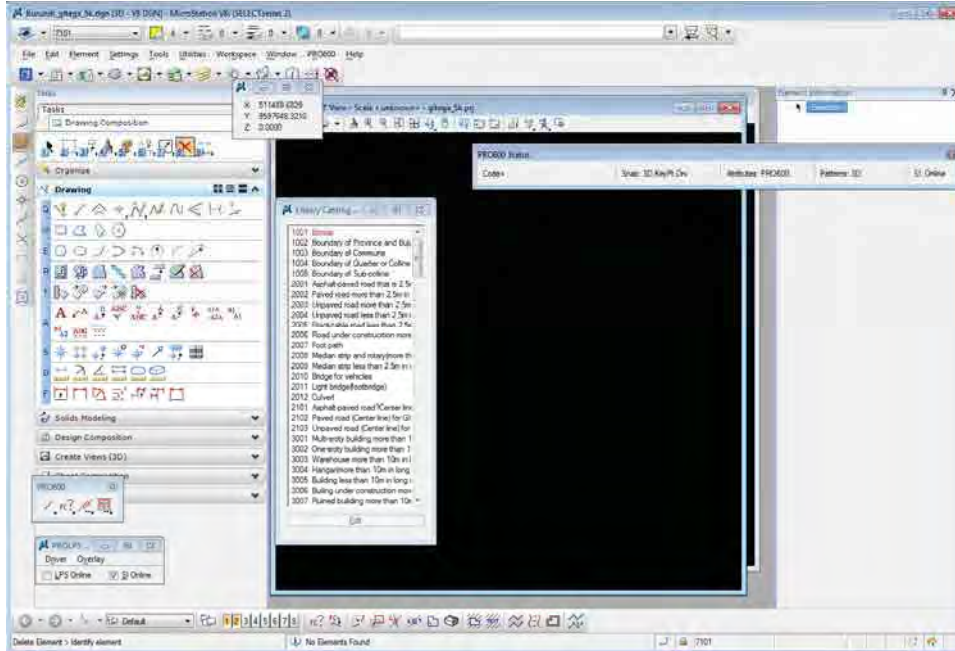
- (23). When the settings in “PRO600 Project” are complete, click “Save Project”.

- (24). Go back to the “Design files” tab in the “PRO600 Project” window. Select a design file (*.dgn) and click “Open DGN File”.

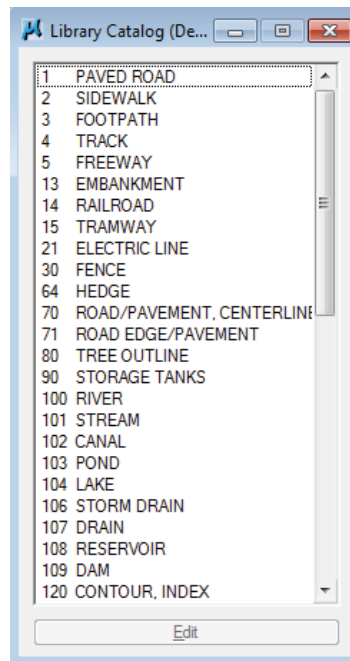


2. Create a Library Catalog

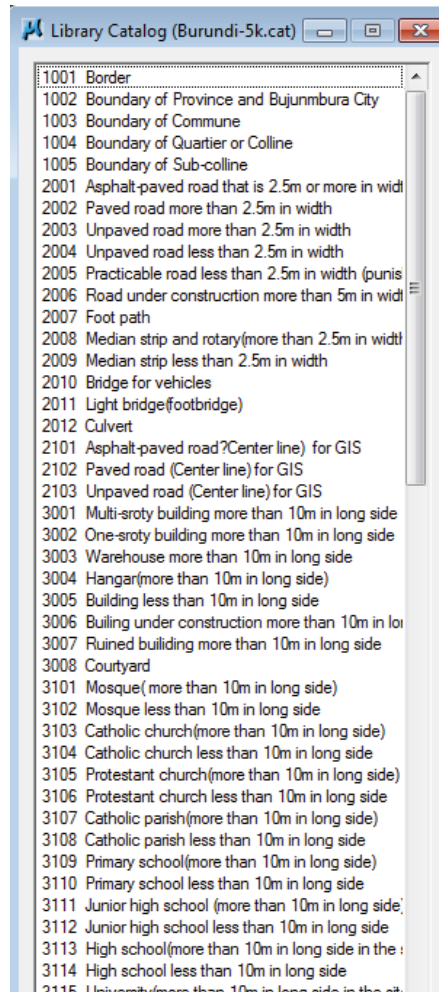
(1). The “MicroStation” and “Leica Photogrammetry Suite – PRO600” are launched.



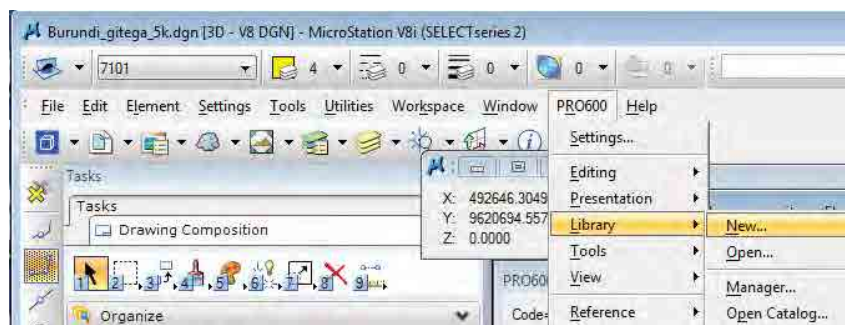
(2). On the default, contents of “Library Catalog” are as shown below.



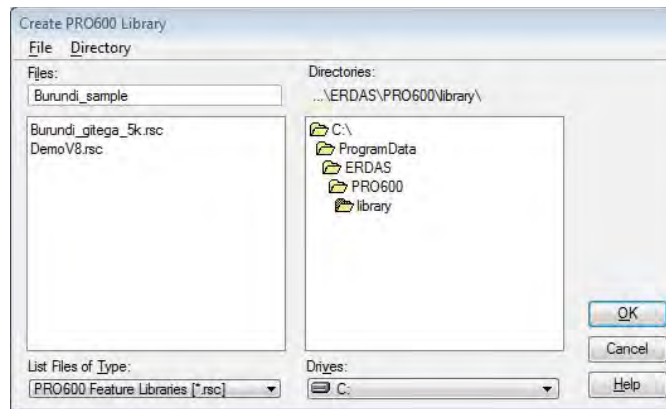
(3). On the other hand, contents of “Library Catalog” for the project are as shown below.



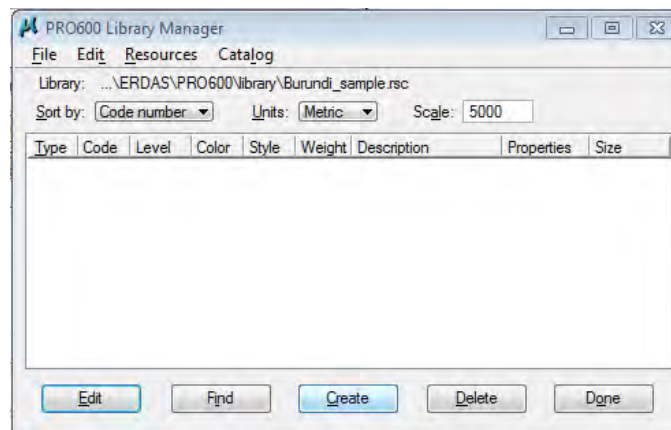
(4). To make a Library Catalog for the project, select **PRO600** > **Library** > **New...** in the MicroStation menus.



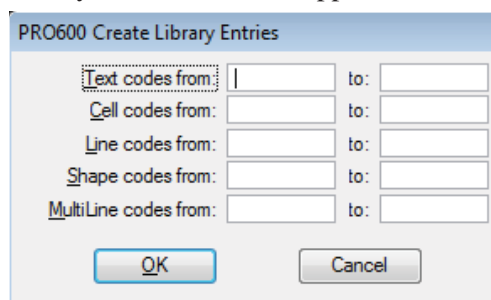
(5). The “Create PRO600 Library” window appears. Type a new file name and click “OK”.



(6). The “PRO600 Library Manager” window appears. Click “Create”.

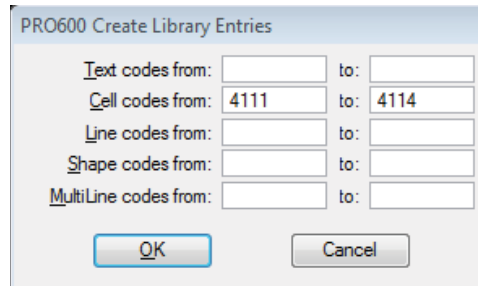


(7). The “PRO600 Create Library Entries” window appears.

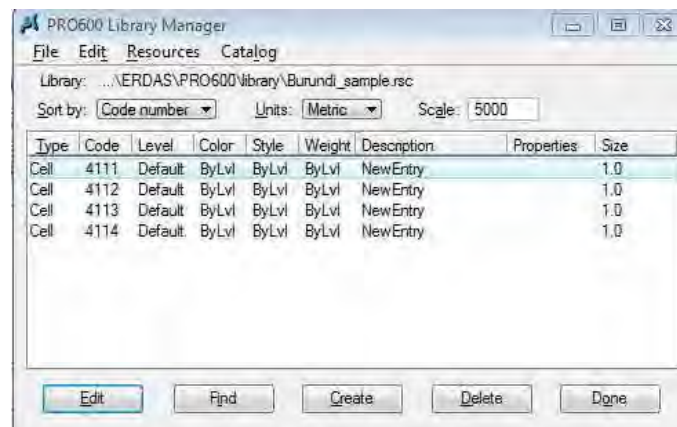


2.1. Point Library

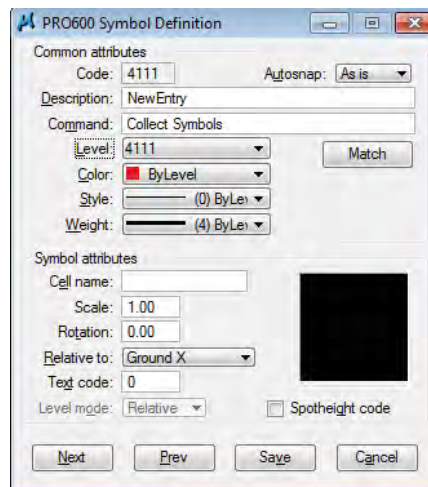
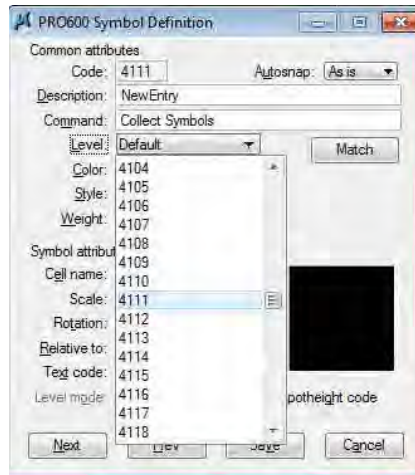
- (1). This is case of point data. Type the code number of geographic features which should be acquired on row of “Cell codes from:” as shown below. And click “OK”.



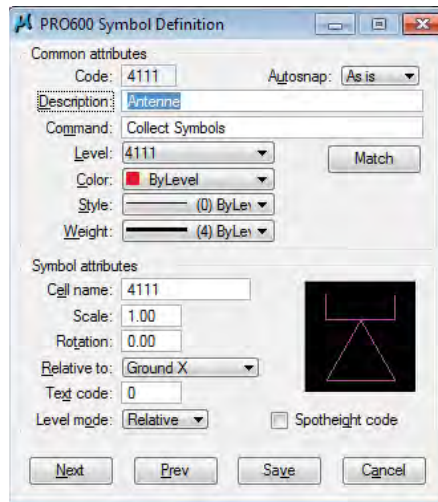
- (2). The contents of “PRO600 Library Manager” shall be displayed as shown below. Click “Edit” for modification.



- (3). In the “PRO600 Symbol Definition” window, type the description such as feature's name at “Description:”. Type command as “Collect Symbols” at “Command:”. Select the same number with code number at “Level”. “Collect Symbols” command is generally used for data acquisition of point data.

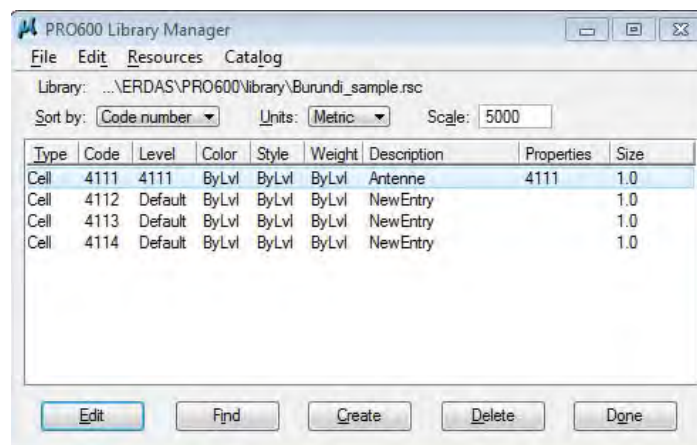


- (4). Type the number which was registered in the cell library file (*.cel) at “Cell name:” under “Symbol attributes”. The symbol which is registered in the cell library file (*.cel) shall be displayed as shown below.

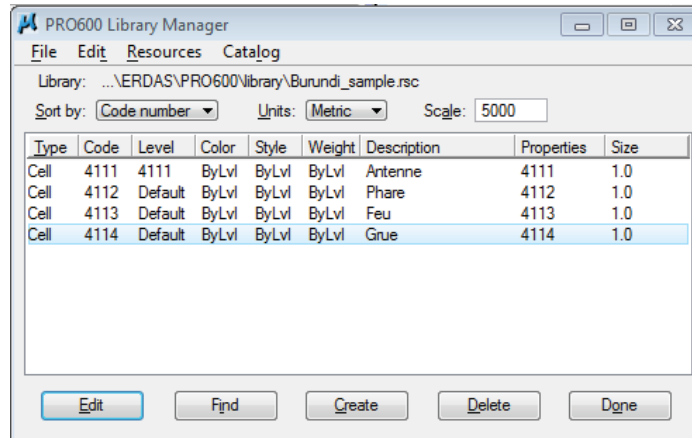


- (5). After complete, click “Save” or “Next”

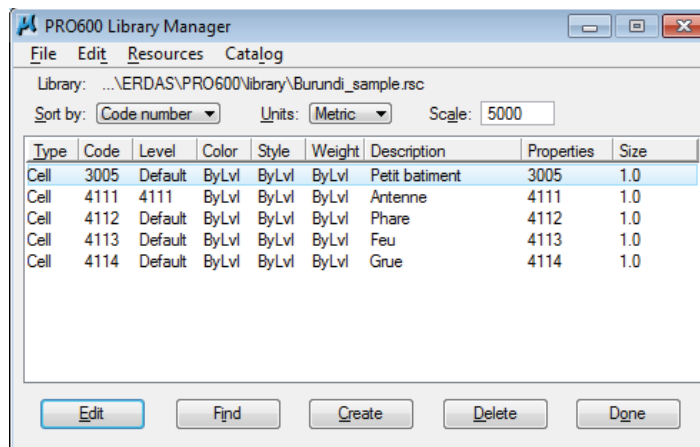
- (6). After click “Save”, the “PRO600 Library Manager” shall be displayed as shown below.



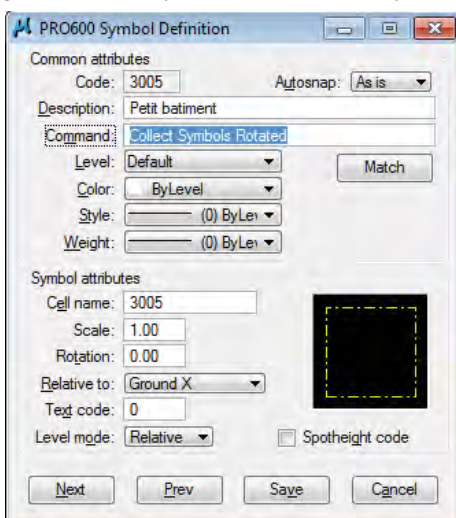
(7). Same progress shall be carried out for others as shown below.



(8). In the case of necessary to give rotation against symbol during plotting work such as small buildings, tower for power line and so on, command at “Command:” in the “PRO600 Symbol Definition” window.

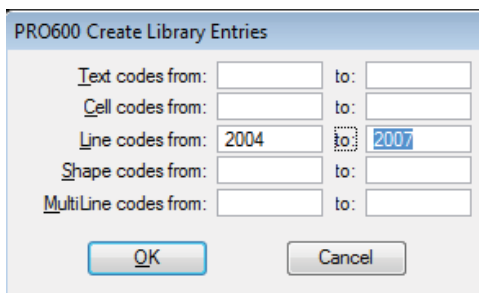


(9). The command for giving rotation to symbol is “Collect Symbols Rotated” as shown below.

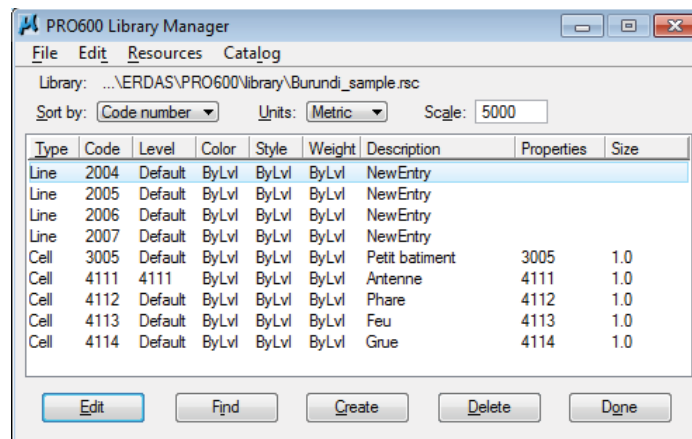


2.2. Line Library

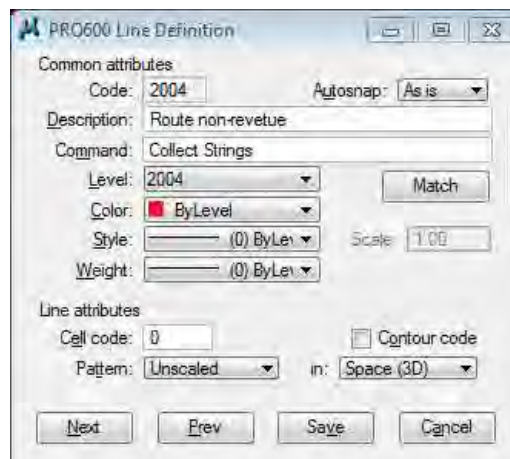
(1). In case of create Line Library, Click "Create" in the "PRO600 Library manager" then "Pro600 Create Library Entries" window appears. Type the code number of geographic features which should be acquired on row of “Line codes from:” as shown below. And click “OK”.



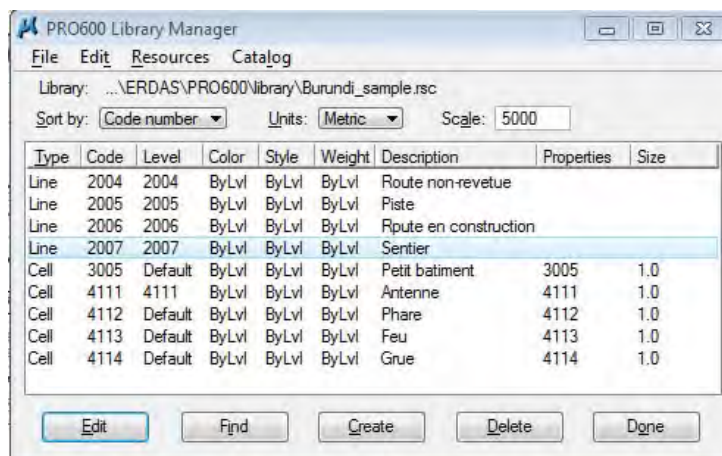
(2). The Contents of “PRO600 Library Manager” shall be displayed as shown below. To edit the content of each library, click “Edit”.



- (3). In the “PRO600 Line Definition” window, type the description such as feature's name at “Description:”. Type command “Collect Strings” at “Command:”. Select the same number with code number at “Level”. “Collect Strings” command is generally used for data acquisition of line data.

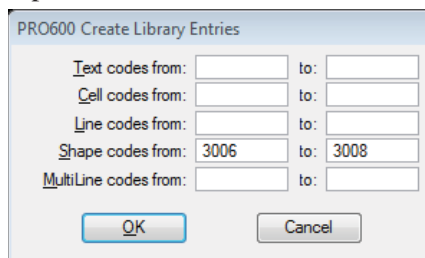


- (4). Same progress shall be carried out for others as shown below.

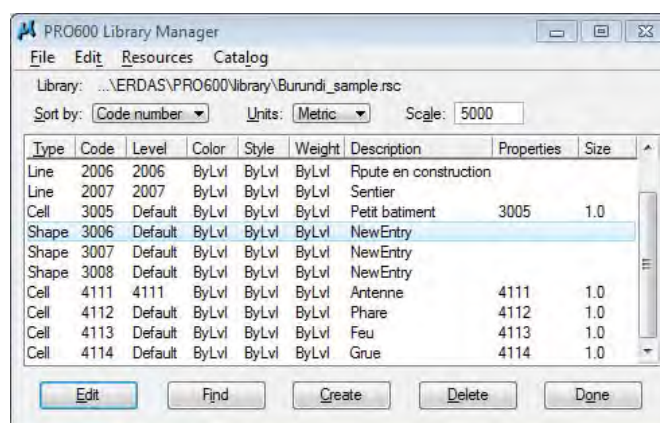


2.3. Polygon Library

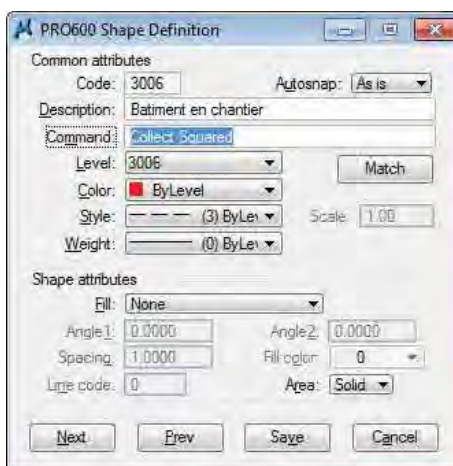
- (1). This is case of polygon data. Type the code number of geographic features which should be acquired on row of “Shape codes from:” as shown below. And click “OK”.



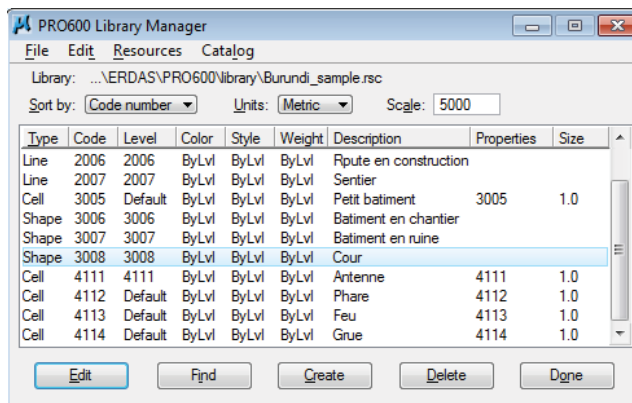
- (2). The Contents of the “PRO600 Library Manager” shall be displayed as shown below.



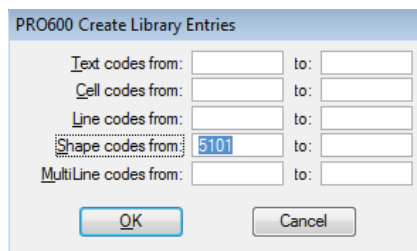
- (3). In the “PRO600 Shape Definition” window, type the description such as feature's name at “Description:”. Type command “Collect Squared” at “Command:”. Select the same number with code number at “Level”. “Collect Squared” command is generally used for data acquisition of polygon data such as buildings.



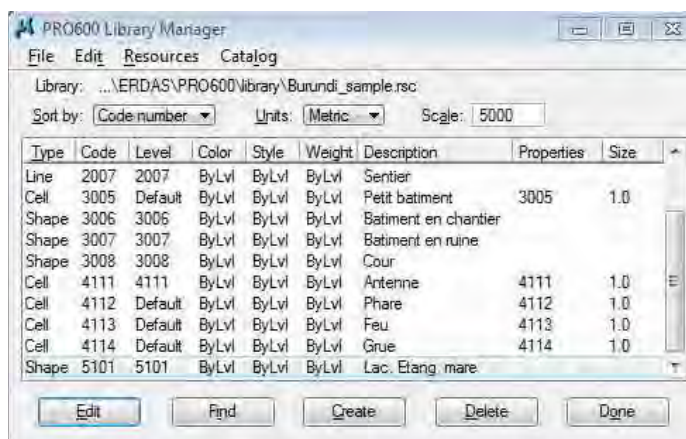
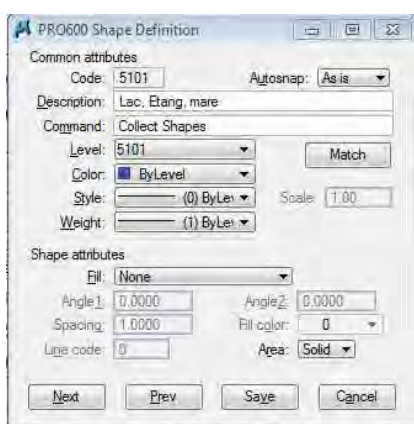
(4). Same progress shall be carried out for others as shown below.



(5). In the case of polygon data but not squared such as lake, the command is different from above mentioned case. The following “5101” indicates lake's code number.

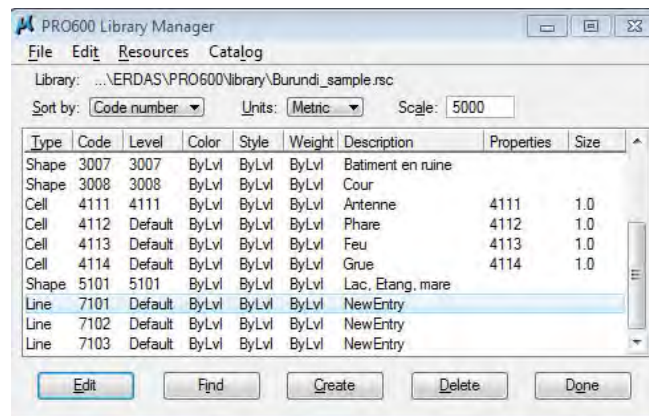
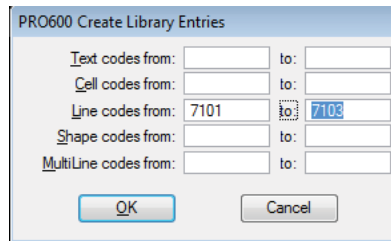


(6). In the “PRO600 Shape Definition” window, type the description such as feature's name at “Description:”. Type command “Collect Shapes” at “Command:”. Select the same number with code number at “Level”. “Collect Shapes” command is generally used for data acquisition of polygon data such as area.

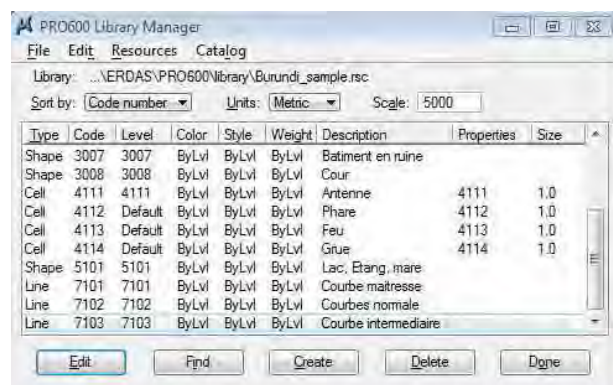
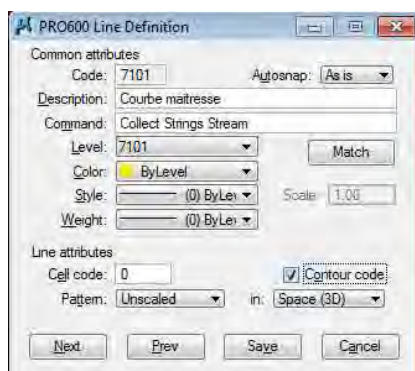


2.4. Contour Library

- (1). In the case of contour data, even if it shall be acquired as line data, the command is different from normal line data.

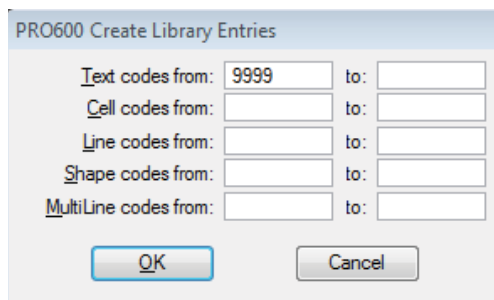


- (2). In the “PRO600 Line Definition” window, type the description such as feature's name at “Description:”. Type command “Collect Strings Stream” at “Command:”. Select the same number with code number at “Level”. “Contour code” under “Line attributes” is checked out.

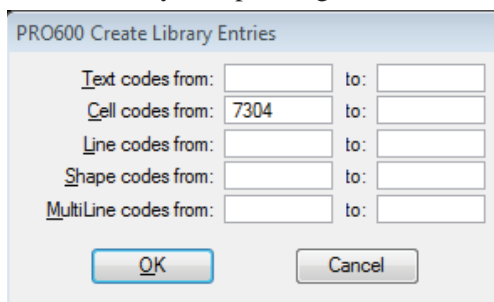


2.5. Spot height Library

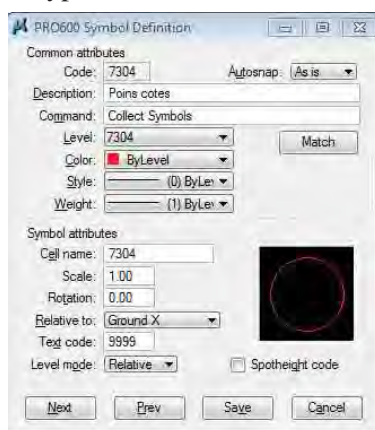
- (1). In the case of spot height, it is different from normal point data because it needs a text code library which shows elevation value. Before spot height is set, the text code shall be created in advance. Here, “7404” which is unused for others is used for the text code.



- (2). After the text code is created, library for spot height is created as shown below.

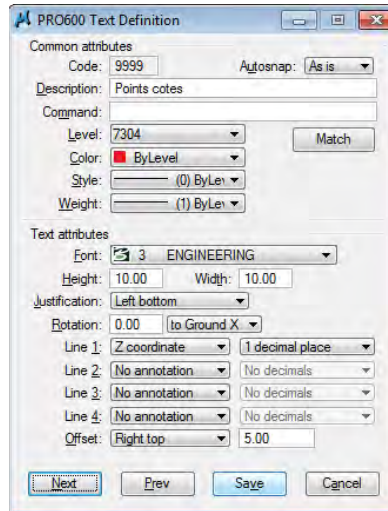


- (3). In the “PRO600 Symbol Definition” window, type the description such as feature's name at “Description:”. Type command “Collect Symbols” at “Command:”. Select the same number with code number at “Level”. “Spotheight code” under “Symbol attributes” is checked out. And “9999” is typed in “Text code:” under “Symbol attributes”.

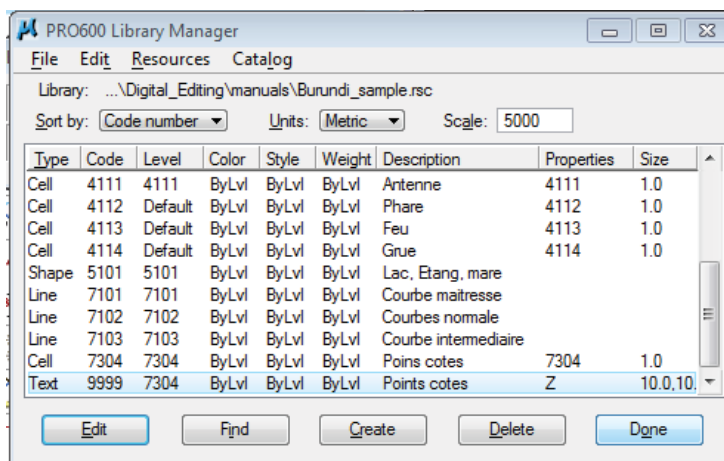


- (4). Open the “PRO600 Text Definition” window for “9999” and type the description such as feature's name at “Description:”. It is unnecessary to type at “Command:”. Select the code number of spot height at “Level”. Some settings such as “Font:” under “Text

attributes” shall be set as shown below. And click “Save”.

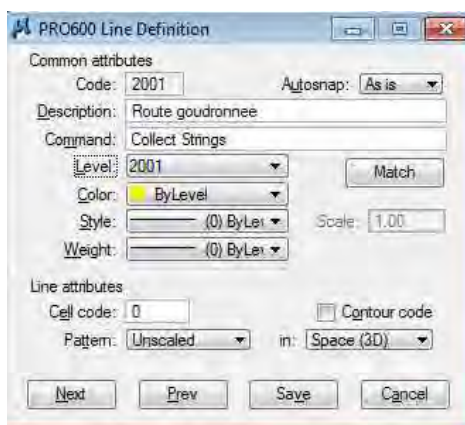
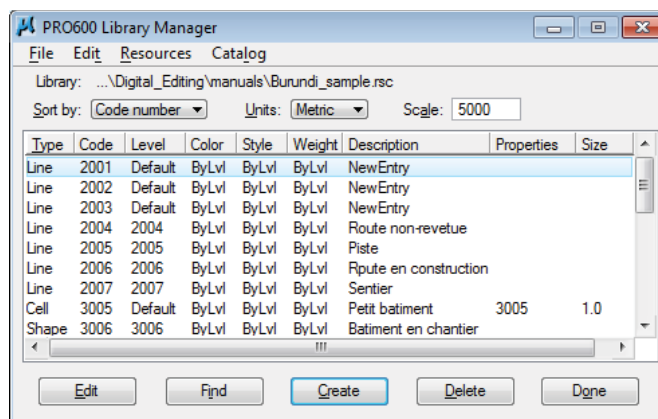


Click "Done" after return to "PRFO600 Library Manager".

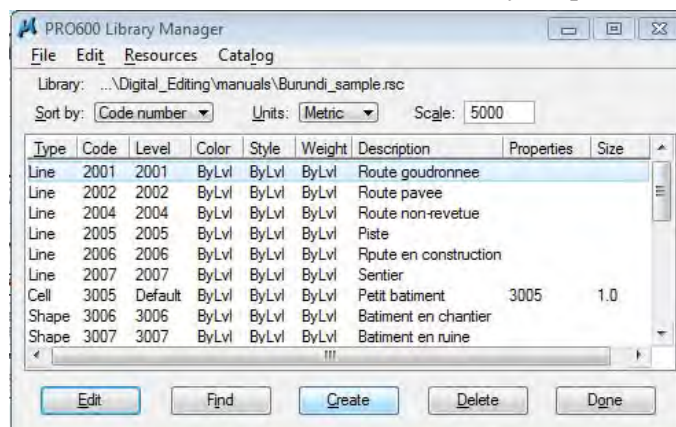


2.6. Parallel line Library

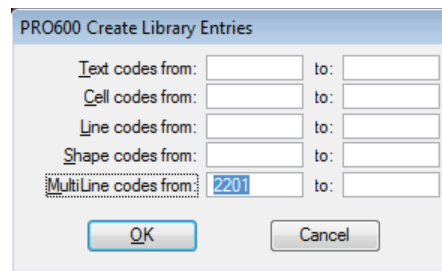
- (1). In the case of width road, its edge line shall be acquired parallel. It is helpful if the data is acquired parallel not one by one. The followings show how to set parallel as an example using “2001”. “2001” shall be created on an equality with normal line data.



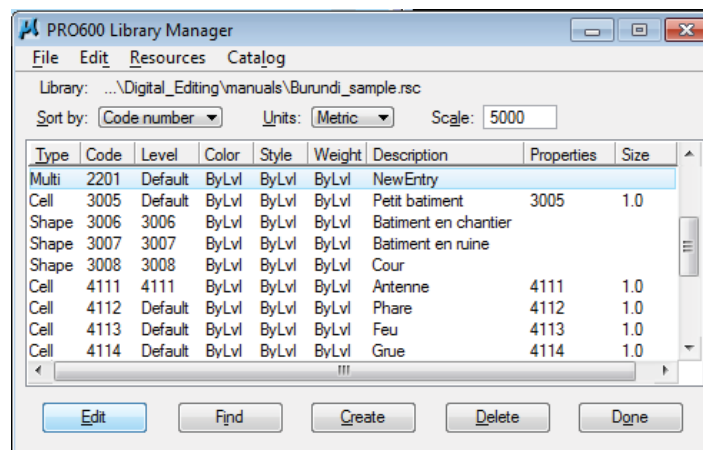
- (2). After creation of “2001”, click “Create” to create a library for parallel line.



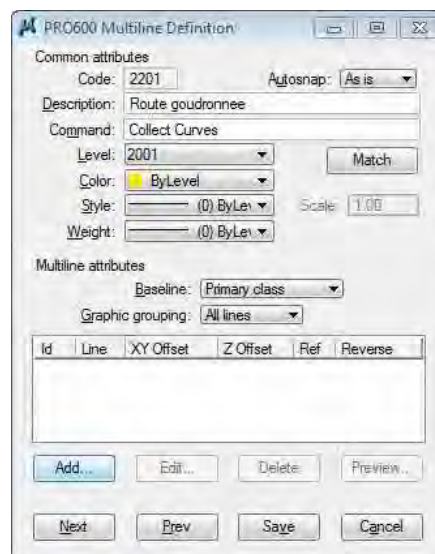
- (3). Type the code number which is unused for others on row of “MultiLine codes from:” as shown below. In this case, Use “2201” as code. And click “OK”.



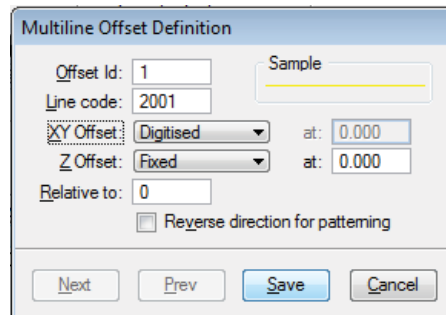
- (4). Select code “2201” and click “Edit”, or double click on “2201” in order to open “PRO600 Multiline Definition”.



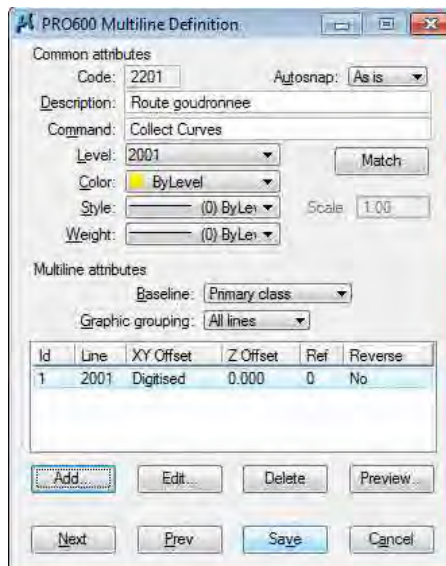
- (5). In the “PRO600 Multiline Definition” window, type the description such as feature's name at “Description:”. Type command “Collect Strings” at “Command:”. Select “2001” at “Level”.



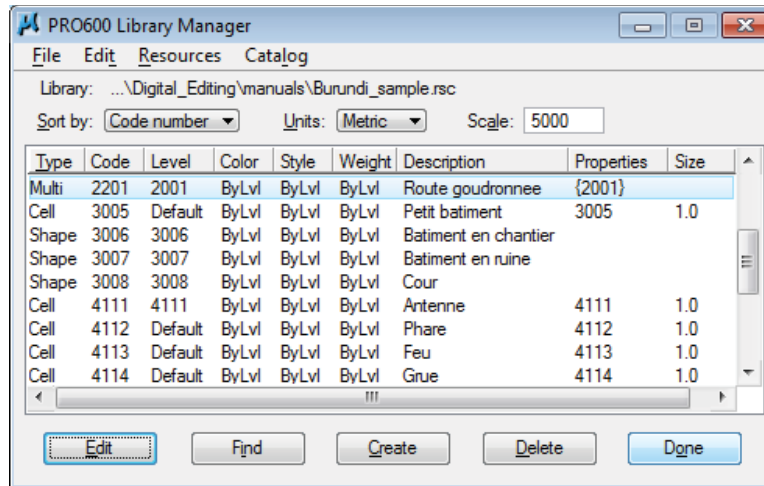
- (6). Click “Add...” under “Multiline attributes” then the “Multiline Offset Definition” window appears. Type and select any parameters as shown below. And click “Save”.



- (7). After click “Save”, the contents of the “PRO600 Multiline Definition” window are shown below. And click “Save”.



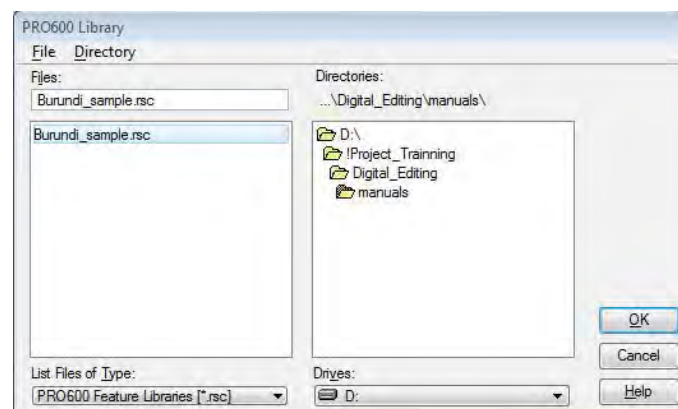
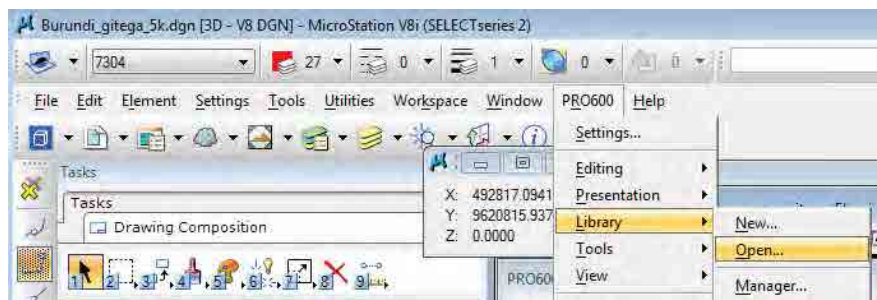
- (8). By doing above mentioned the way of creating libraries, it is possible to create necessary libraries of point, line and polygon data. Finally, click “Done” in the "PRO600 Library Manager".



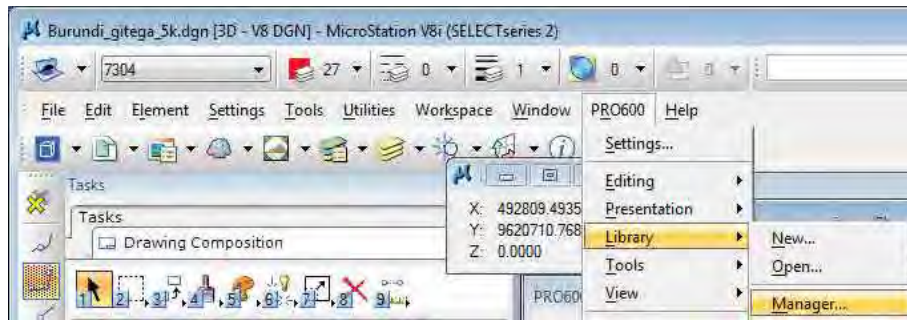
2.7. Library Manager

(1). These are how to open the Library Manager.

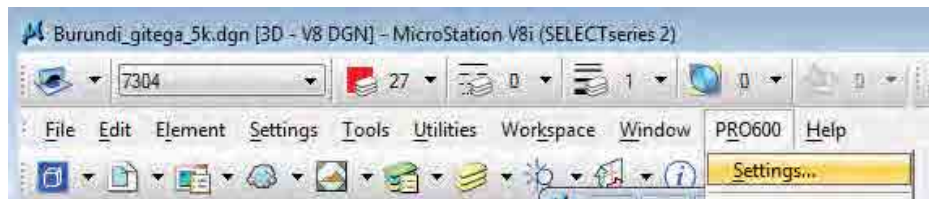
- ✧ Select **PRO600 > Library > Open...** in the MicroStation menus. Select the appropriate PRO600 Library (*.rsc) file in “PRO600 Library” window.



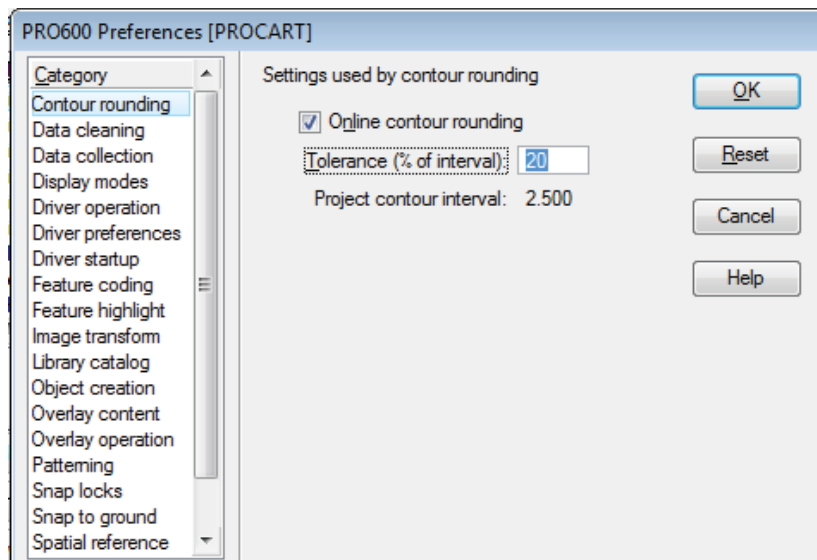
- ✧ Select **PRO600 > Library > Manager...** in the MicroStation menus. The appropriate PRO600 Library (*.rsc) file is opened.



- (2). To draw the contour data, the following setting needs. Select **PRO600** > **Settings...** in the MicroStation menus.



- (3). In the “PRO600 Preferences” window, check on “Online contour rounding” and type “20” on “Tolerance (% of interval):”. This means that the elevation of contour data which is within 20% range of contour interval shall be round onto value of its interval during plotting. For example, 1.20m rounds to 1.00m. similarly, 0.8m rounds to 1.00m.

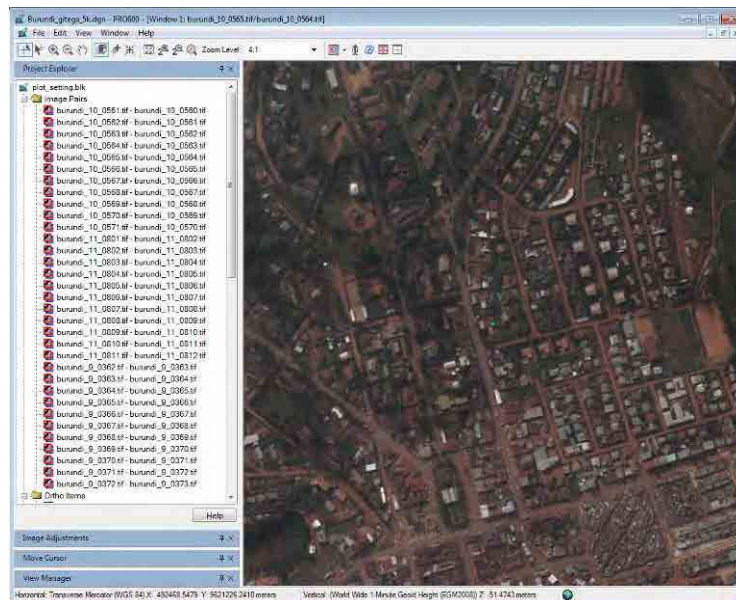


3. Setting of TopoMouse

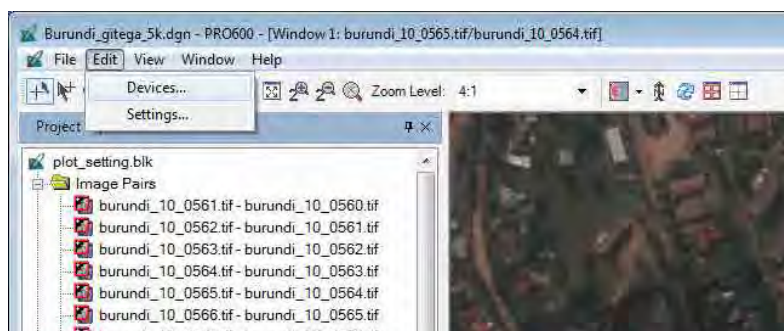
(1). TopoMouse which is shown below must be set for data acquisition.



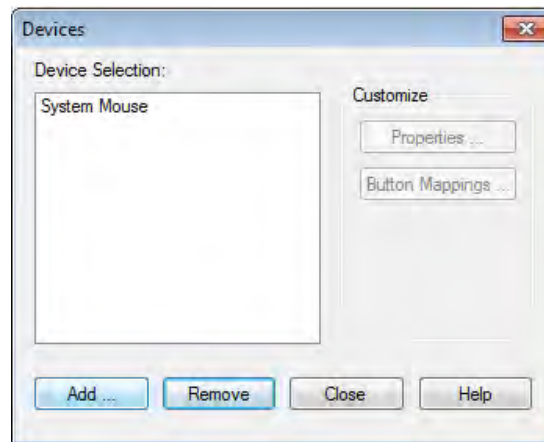
(2). The “Leica Photogrammetry Suite – PRO600” window displays aerial photos as shown below.



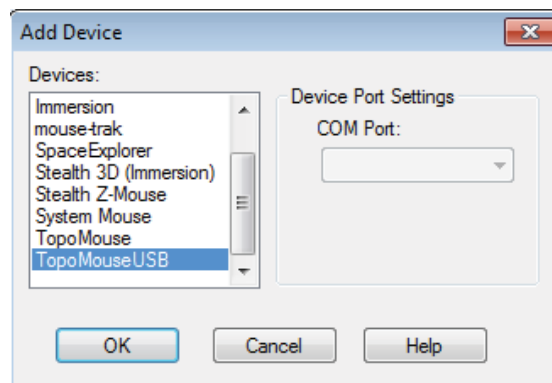
(3). To set the TopoMouse, select **Edit > Devices...** in the menus as shown below. The TopoMouse is not recognized automatically in LPS when it just connects to computer.



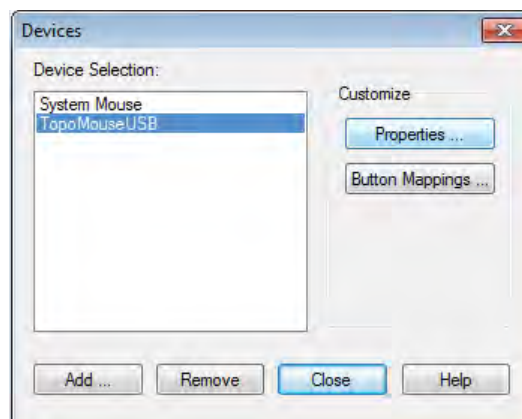
(4). In the “Devices” window, click “Add...”



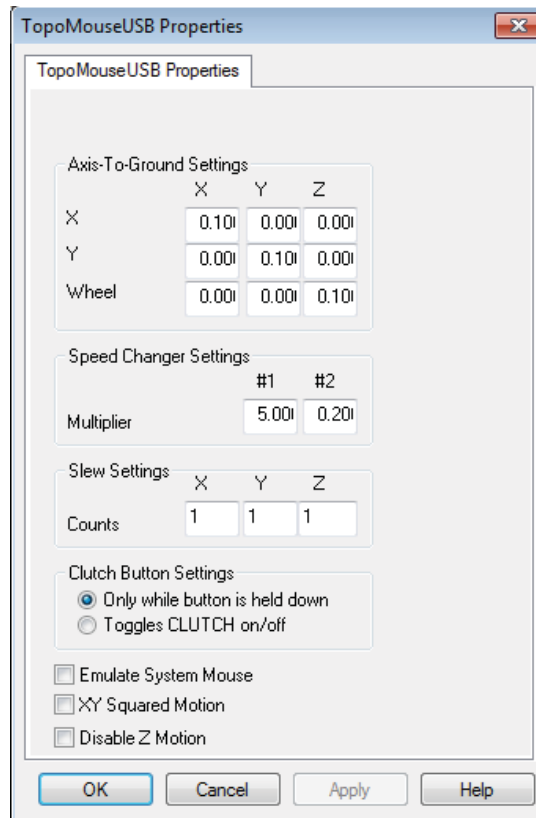
(5). The “Add Device” window appears. Select “TopoMouseUSB” and click “OK”.



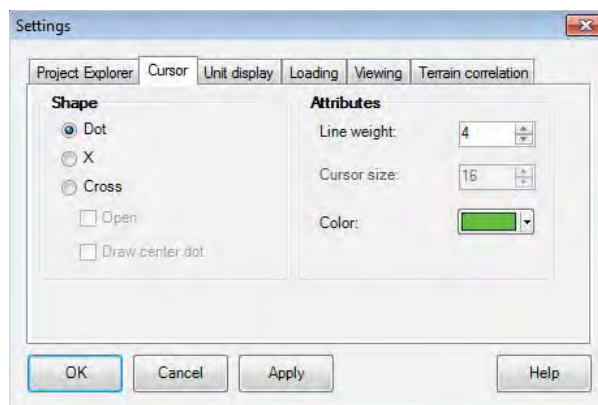
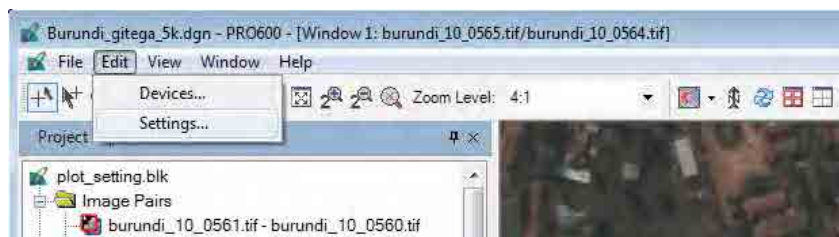
(6). “TopoMouseUSB” is listed in the “Devices” window. Click “Properties...” after select “TopoMouseUSB”.



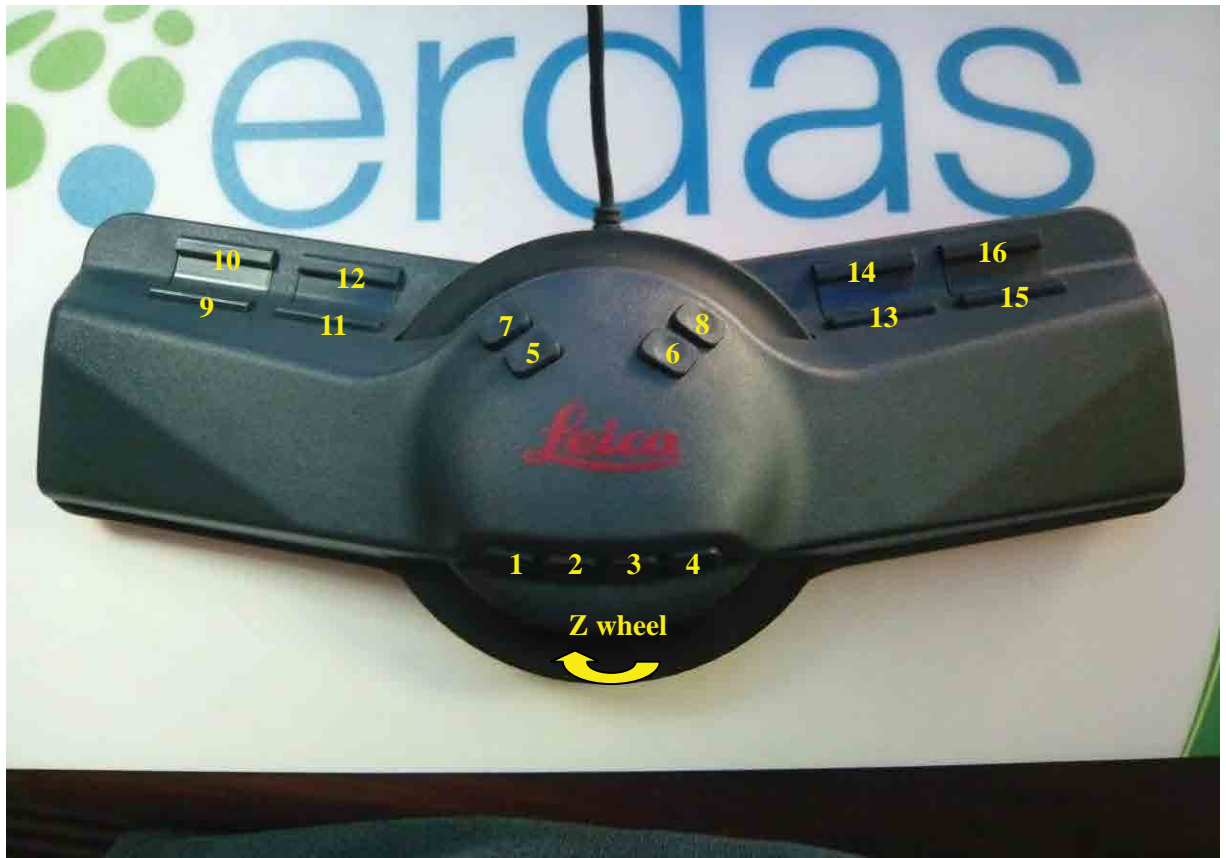
(7). The “TopoMouseUSB Properties” window appears. The parameters are set as shown below.



(8). It is possible to change the cursor style of TopoMouse.



TopoMouse consist of 16 buttons and a Z wheel as shown below. All buttons have each function. In this manual, explanation of each function skips.



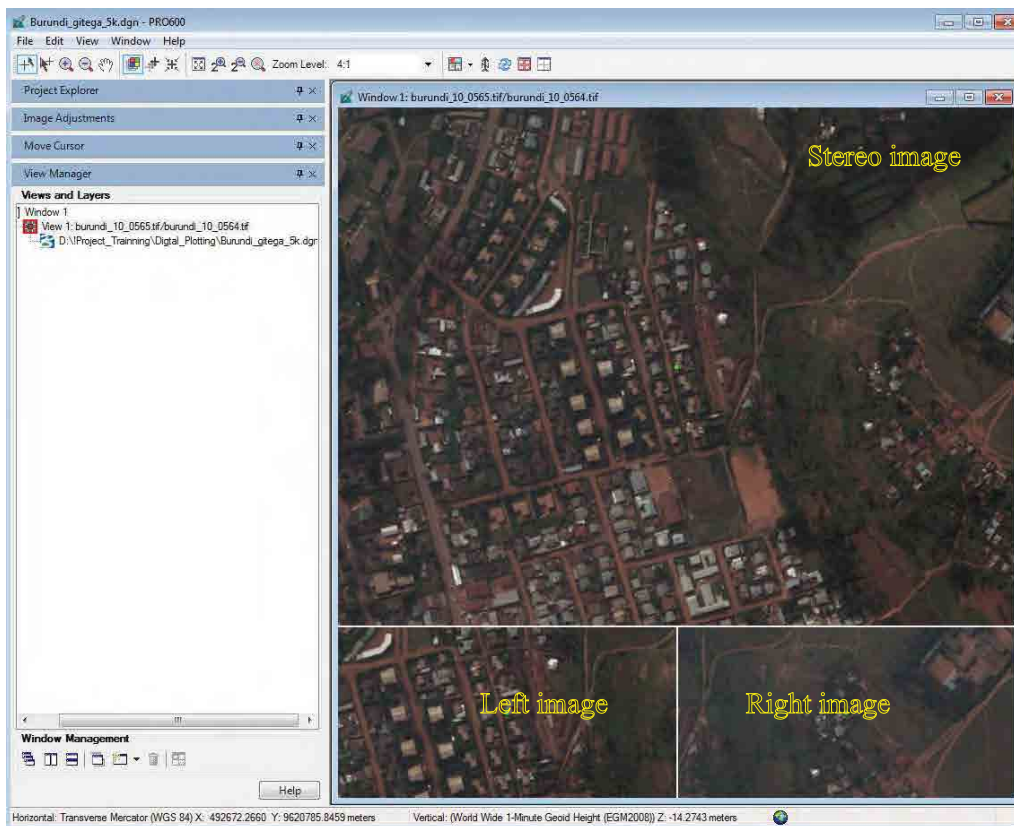
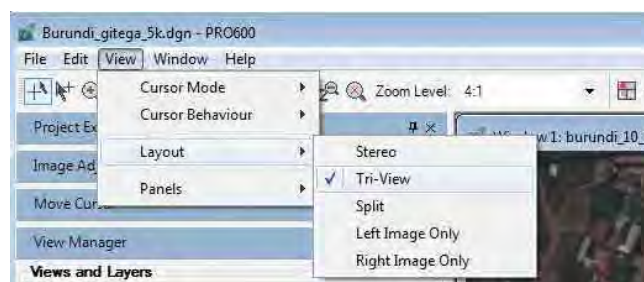
Note: For further information of TopoMouse, see the manuals by Leica in the following address.
Installation drive\Program Files\Leica Geosystems\PRO600\Acrobat\English\Propls.pdf

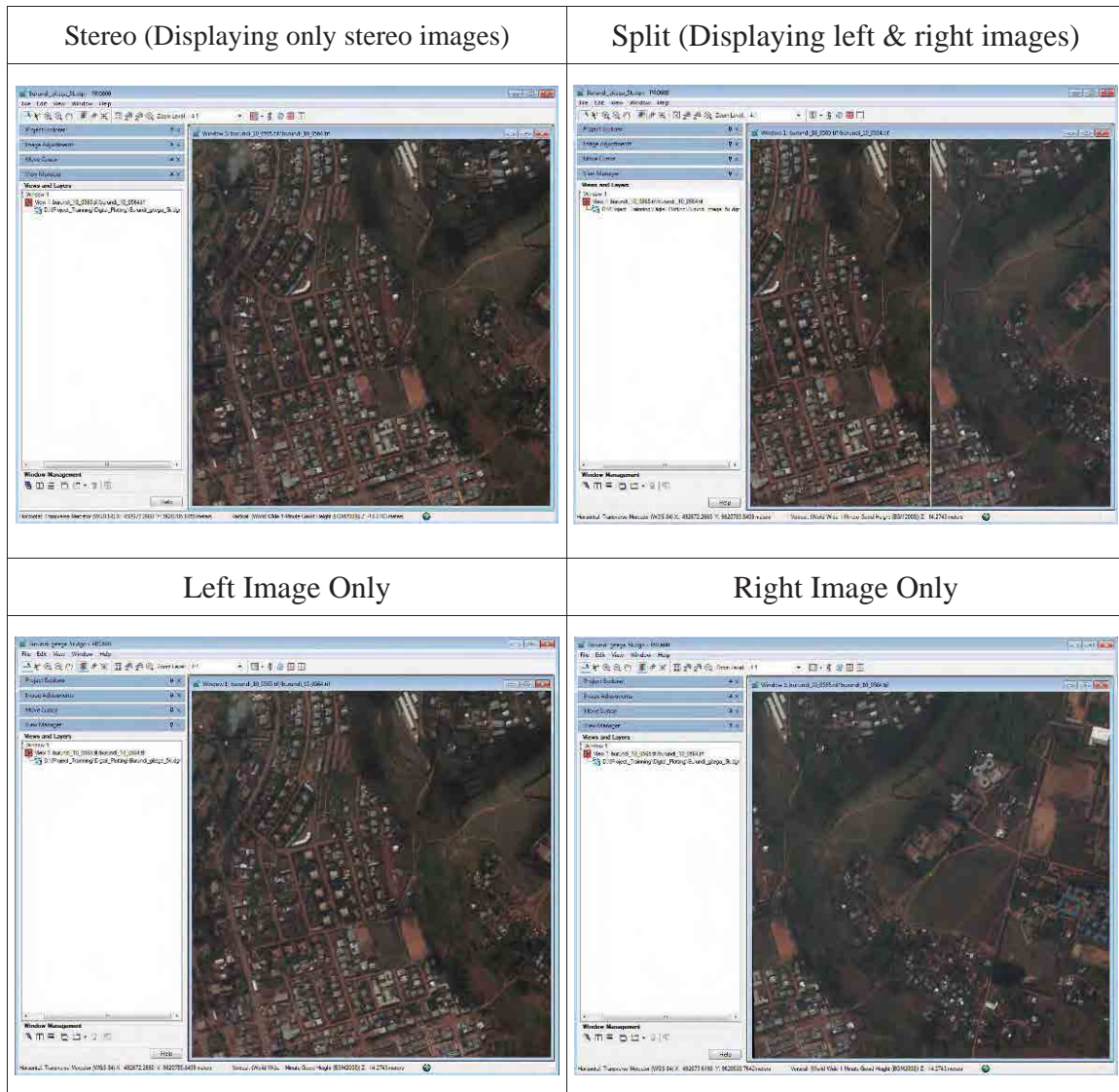
(9). During acquisition of the data, height information of all features has to be acquired with Z whole of TopoMouse accurately. The followings show samples in cases of accurate and not.

4. Displaying stereo models

- (1). In LPS, there are 5 options for displaying stereo model as shown below. (In this manual, it is impossible to show condition of stereo image. Stereo images is shown like a single image)

The “Tri-View” is recommended for beginners because it is possible to confirm a cursor among stereo image, left image and right image at a once.

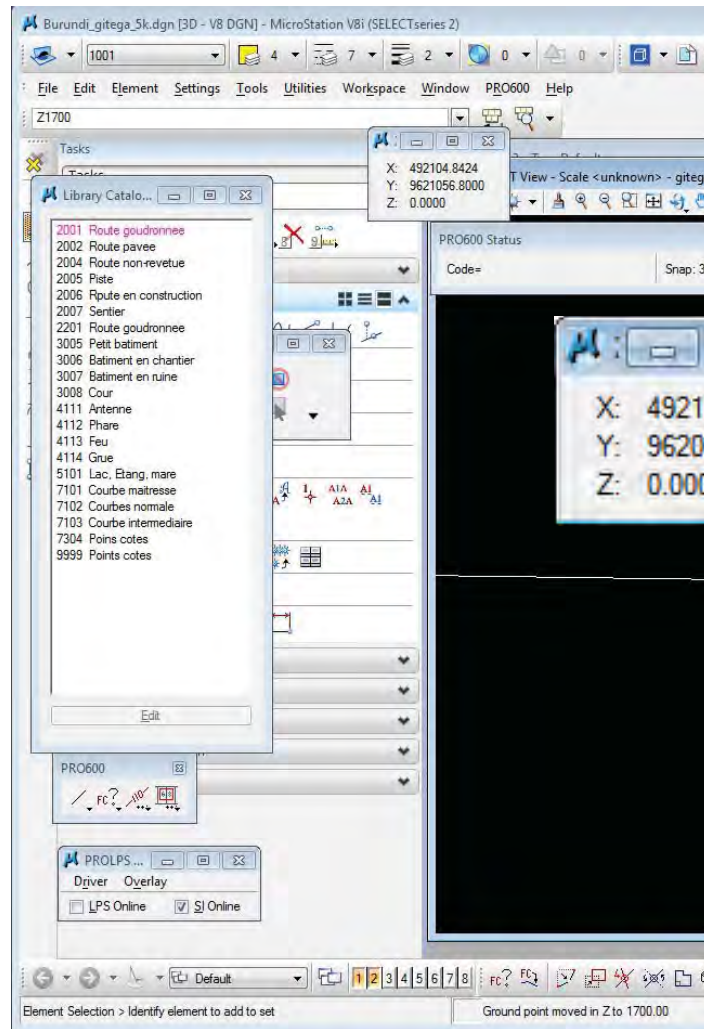




(2). The followings show how to set specified Z value (height).

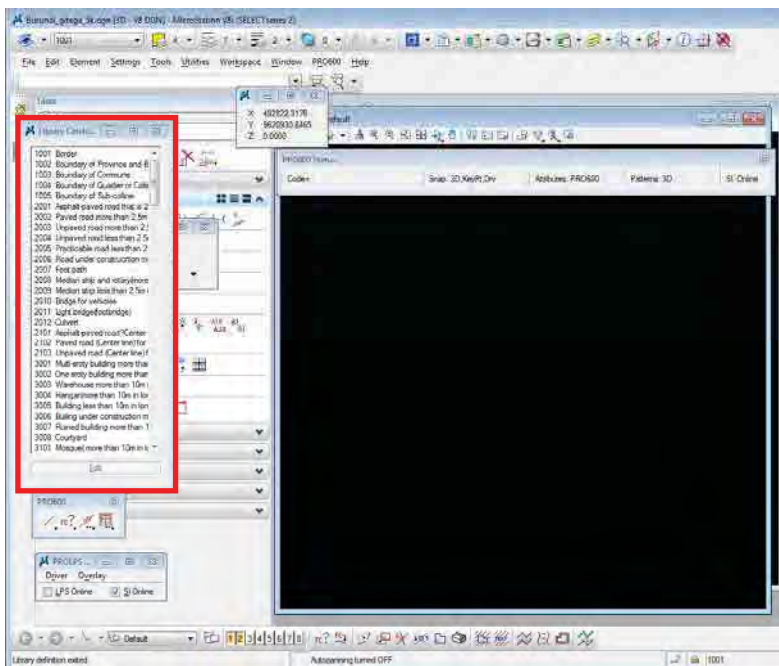
When typing Z** (** indicates digit) in the command line and press “Enter”, Z value set ** m.

The following example shows how to set Z value to 10m.



5. Data acquisition

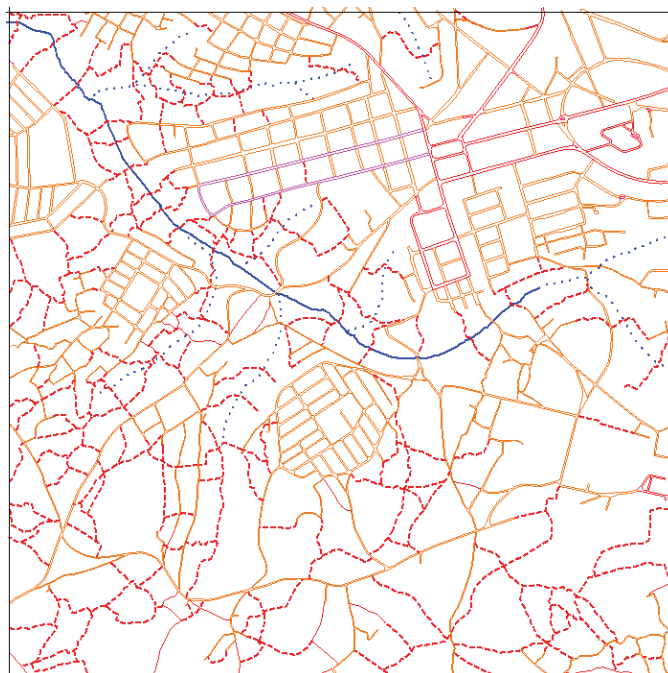
- (1). The appropriate library must be selected in the Library Catalog before the data acquisition as shown below.



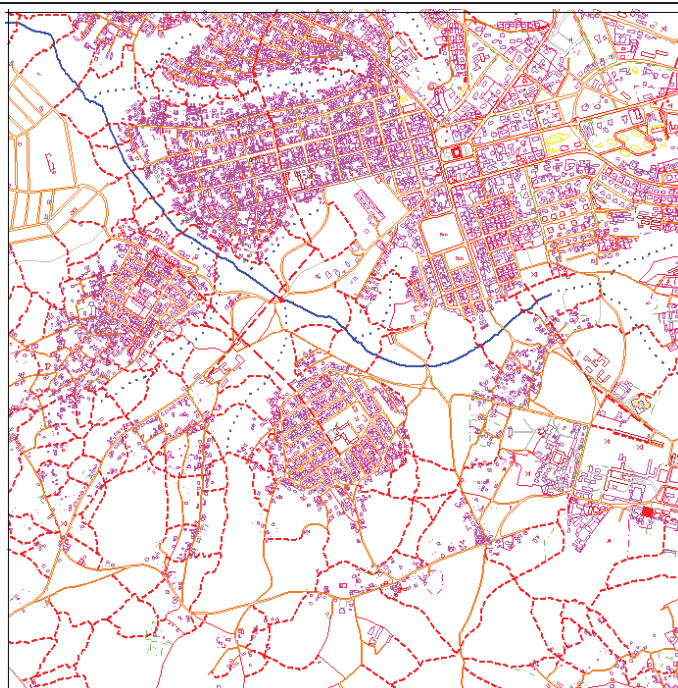
In the case of 2003	In the case of 3001	In the case of 7101
<p>Library Catalog (Burundi-5...)</p> <ul style="list-style-type: none"> 1001 Border 1002 Boundary of Province and Bujumbura City 1003 Boundary of Commune 1004 Boundary of Quartier or Colline 1005 Boundary of Sub-colline 2001 Asphalt-paved road that is 2.5m or more in 2002 Paved road more than 2.5m in width 2003 Unpaved road more than 2.5m in width 2004 Unpaved road less than 2.5m in width 2005 Practicable road less than 2.5m in width (p 2006 Road under construction more than 5m in 2007 Foot path 2008 Median strip and rotary(more than 2.5m in v 2009 Median strip less than 2.5m in width 2010 Bridge for vehicles 2011 Light bridge(footbridge) 2012 Culvert 2101 Asphalt-paved road?Center line) for GIS 2102 Paved road (Center line) for GIS 2103 Unpaved road (Center line) for GIS 3001 Multi-story building more than 10m in long s 3002 One-story building more than 10m in long si 3003 Warehouse more than 10m in long side 3004 Hangar(more than 10m in long side) 3005 Building less than 10m in long side 3006 Builing under construction more than 10m i 3007 Ruined building more than 10m in long sid 3008 Courtyard 3101 Mosque(more than 10m in long side) 3102 Mosque less than 10m in long side <p>Edit</p>	<p>Library Catalog (Burundi-5...)</p> <ul style="list-style-type: none"> 2101 Asphalt-paved road?Center line) for GIS 2102 Paved road (Center line) for GIS 2103 Unpaved road (Center line) for GIS 3001 Multi-story building more than 10m in long s 3002 One-story building more than 10m in long si 3003 Warehouse more than 10m in long side 3004 Hangar(more than 10m in long side) 3005 Building less than 10m in long side 3006 Builing under construction more than 10m i 3007 Ruined building more than 10m in long sid 3008 Courtyard 3101 Mosque(more than 10m in long side) 3102 Mosque less than 10m in long side 3103 Catholic church(more than 10m in long side 3104 Catholic church less than 10m in long side 3105 Protestant church(more than 10m in long si 3106 Protestant church less than 10m in long sic 3107 Catholic parish(more than 10m in long side) 3108 Catholic parish less than 10m in long side 3109 Primary school(more than 10m in long side) 3110 Primary school less than 10m in long side 3111 Junior high school (more than 10m in long : 3112 Junior high school less than 10m in long sic 3113 High school(more than 10m in long side in l 3114 High school less than 10m in long side 3115 University(more than 10m in long side in th 3116 University less than 10m in long side 3117 Hospital(more than 10m in long side) 3118 Hospital less than 10m in long side 3119 Health center or clinic(more than 10m in lor <p>Edit</p>	<p>Library Catalog (Burundi-5...)</p> <ul style="list-style-type: none"> 6006 Farmland (mixed plantation) 6007 Swamp farmland 6008 Paddy field 6009 Green belt 6010 Boundary of national park 6011 Row of trees more than 50m in length 6101 Eucalyptus 6102 Palm tree 6103 Banana 6104 Coffee 6105 Tea 6106 Sugar cane 6107 Cotton 6108 Papyrus 7101 Index contour (25m) 7102 Principal contour (5m) 7103 Intermediate contour (2.5m) 7104 Depression contour (Index) (25m) 7105 Depression contour (Principal) (5m) 7201 Embankment more than 50m in length and 7202 Steep slope more than 50m in length and : 7203 Thalweg more than 500m in length 7204 Soil : rocks 7205 Soil : Sand 7301 Original Control point 7302 Photo control point 7303 Bench mark 7304 Spot elevation 7305 NewEntry 9999 Spot height <p>Edit</p>

(2). The following pictures show sample of the order of data acquisition.

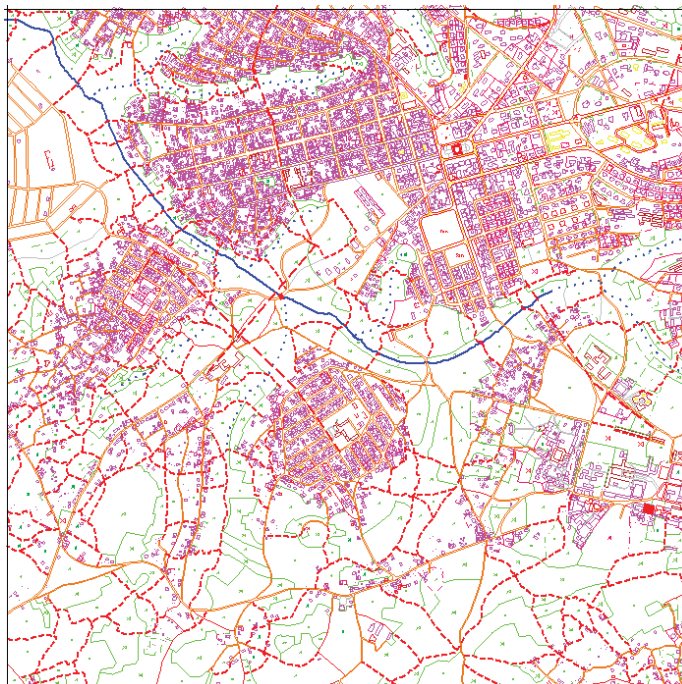
A) Line data which shall be bones. (road, railway, river, canal, lake, shore line, power line, pipe line and so on)



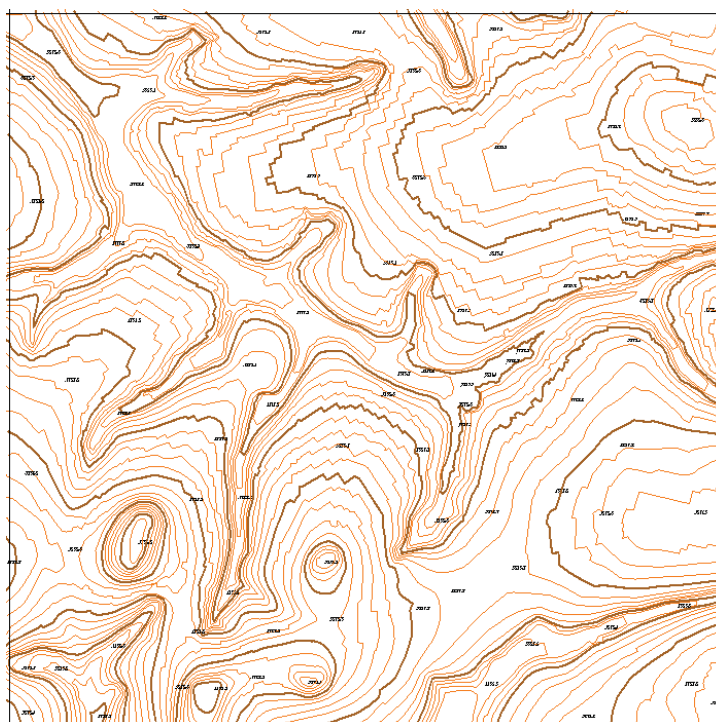
B) Data of buildings, small objects, land marks and plottage. (various buildings, fences, revetments, wells, various tanks, transformer stations, various towers, cemeteries and so on)



C) Vegetation data (rice field, crop field, orchard, various plantation, forest, bush and so on)



D) Terrain data (contour, cliff, spot height and so on)



Note: For further information of LPS, see the manuals by Leica in the following address.
Installation drive\Program Files\Leica Geosystems

Digital Compilation

The Basic Operation manual of MicroStation

<Objective>

For understanding about “Digital plotting”, “Digital compilation” and “Symbolization”, it is necessary to understand the manipulation of the “MicroStation” basically. This document mentions elementary manipulations.

<Required Basic Manipulations for the training>

1. View Control Menu

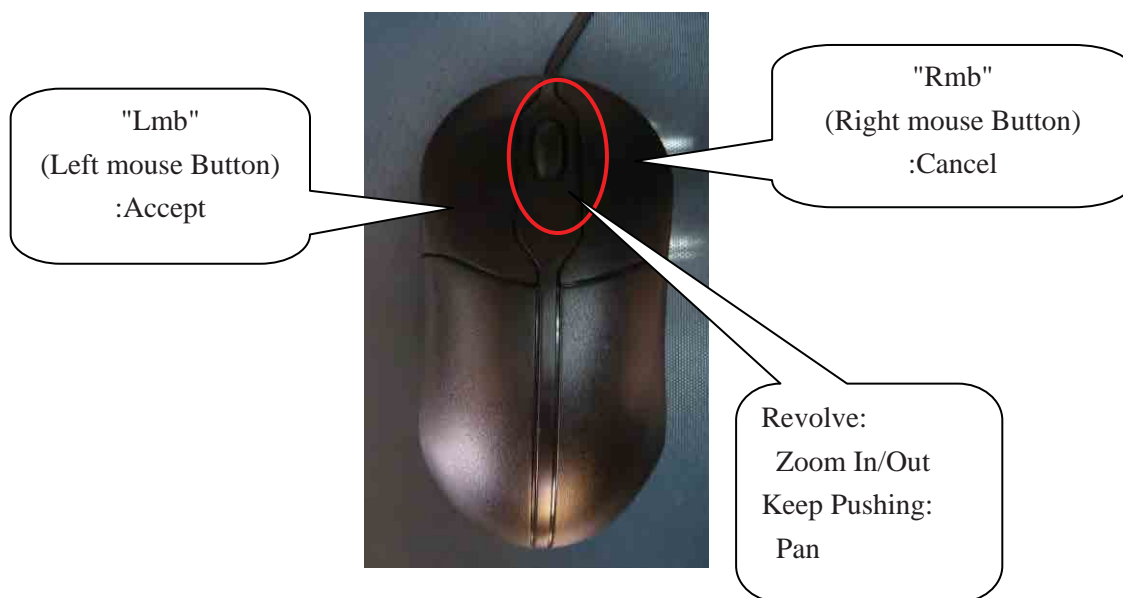
2. Drawing Menu

3. Main Menu

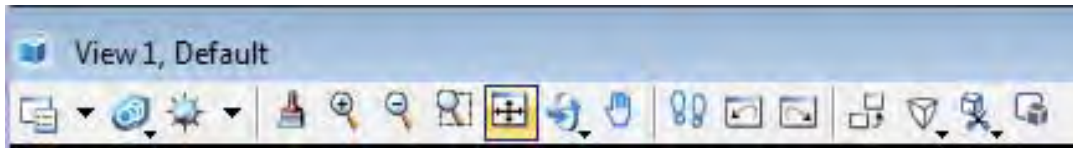
4. Other Useful Menu

5. File Setting

<Mouse Control>



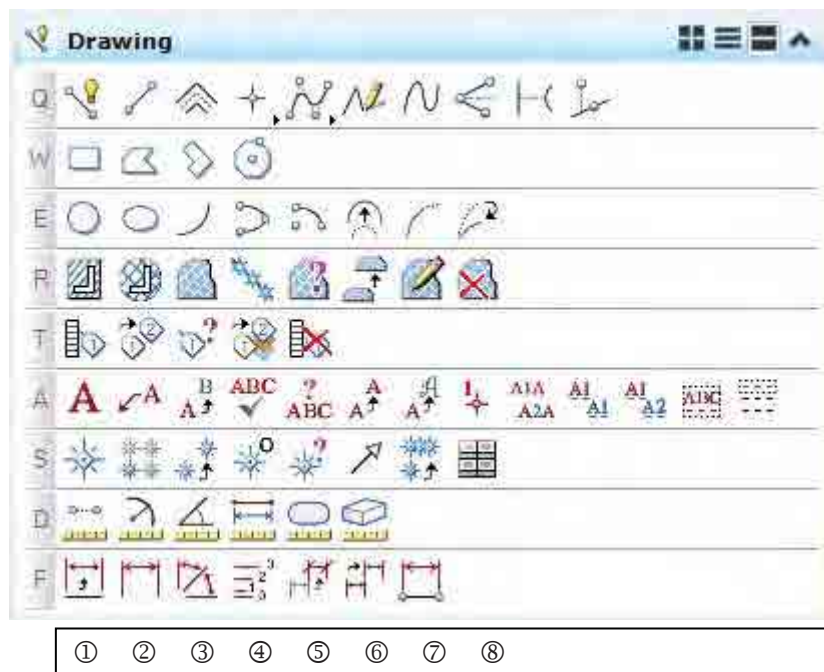
1. View Control Menu



V1	①	②	③				
V2			①	②	③	④	⑤ ⑥ ⑦
V3						①	② ③
V4							① ② ③ ④

ID	Command	Contents	Action
V1: View Setting	① View Attribute	Set View Attribute	Click Icon then active required attribute in the setting window
	② Display Styles	Define Display Style	Click Icon then choose proper style in the setting window
	③ Adjust View Brightness	Change View Brightness	Click Icon then move bar on proper brightness
V2: View Control	① Update View	After modification, Update the result of modification.	Click Icon then “Lmb” in the view
	② Zoom In	Increase the magnification of a view.	Click Icon then “Lmb” in the view
	③ Zoom Out	Decrease the magnification of a view.	Click Icon then “Lmb” in the view
	④ Window Area	Define the showing area in the view.	Click Icon then “Lmb” at the Upper left and “Lmb” at the Lower right of the area
	⑤ Fit View	Show all data and fit into the View.	Click Icon
	⑥ View Rotation	Define View Rotation (Direction)	Click Icon 1-2 second then Choose proper rotation
	⑦ Pan View	Move the center of view	Click Icon then “Lmb” in the view and move cursor (“Lmb” for Decide, “Rmb” for Cancel)
V3: Walk and UNDO	① Walk	Rotate view interactively	Click Icon then set in the window
	② Go to Previous View	Undo	Click Icon
	③ Go to Next View	Redo	Click Icon
V4: Advanced View Control	① Copy View	Copy active view	Click Icon then Open new view then “Lmb” in the new view
	② View Perspective	Change View Perspective	Click Icon then “Lmb” in view and move cursor
	③- Advanced functions	“See Help”	

2. Drawing Menu

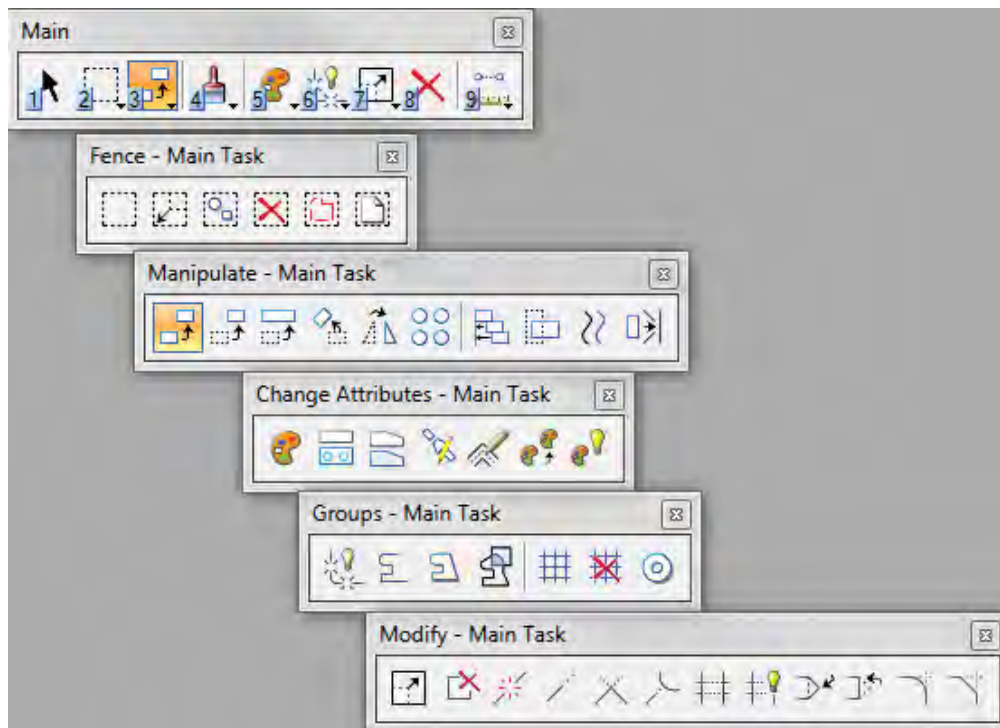


ID	Command	Contents	Action
Q: Draw line and point	① Place Smart line	Draw a continuous line	Click Icon then “Lmb” on each point until last point and “Rmb” after last point
	② Place Line	Draw a line by 2 points (Start and End) lines	Click Icon then “Lmb” on each point until last point and “Rmb” after last point
	③ Place Multi-Line	Create parallel line	Click Icon then set Styles in the window and Draw line
	④ Place Active Point	Create points	Click Icon then a choose function then Place points
	⑤ B-Spline by Points	Create Stream Line by Arc Segment	Click Icon then “Lmb” on each point until last point and “Rmb” after last point
	⑥ Place Stream Line String	Create Stream Line by “hold-down”mode	Click Icon then Push "Lmb" then move cursor
	⑦ Place Point or Stream Curve	Create Stream Line by points	Click Icon then “Lmb” on each point until last point and “Rmb” after last point
	⑧- Advanced functions	“See Help”	
W: Draw Polygon	① Place Block	Create Rectangle	Click Icon then “Lmb” at the Upper left of the area and Click “Lmb” at the Lower right
	② Place Shape	Create shape(Polygon)	Click Icon then “Lmb” on each point until last point and Click “Close Element”

	③	Place Orthogonal Shape	Create shape(Polygon) with "right angle" mode	Click Icon then "Lmb" on each point until last point and Click "Lmb"
	④	Place Regular Polygons	Create shape(Polygon) with defined edges	Click Icon then set Edges and "Lmb" on the center of Polygon then decide size
E: Draw Arc	①	Place Circle	Create Circle	Click Icon then "Lmb" on the center of Circle and decide size
	②	Place Ellipse	Create Ellipse	Click Icon then "Lmb" on the center and decide direction then decide size
	③-	Advanced functions	"See Help"	
R: Hatch	①	Hatch Area	"See Help"	
	②			
	③			
	④- ⑦	Advanced functions	"See Help"	
	⑧			
T: Tag			"See Help"	
A: Text(Annotation)	①	Place Text	Put Text(Annotation, Comment, etc)	Click Icon then Type text into the "Text Editor" and set styles then Click "Lmb" on the point in the Window
	②-	Advanced functions	"See Help"	
S: Cell(Symbol)	①-	Place active Cell	"Symbolization"	
D: Distance	①	Measure Distance	Measure the distance between 2 points.	Click Icon then "Lmb" on each point from 1 st point and 2 nd point, then see "Measure Distance" window.
	②-	Advanced functions	"See Help"	
F: Dimension	①-	Advanced functions	"See Help"	

Notice: "See Help" means Go to "Help"-> "Tool Index" and Type keywords in dialog box" into "Index" Tag.

3. Main Menu

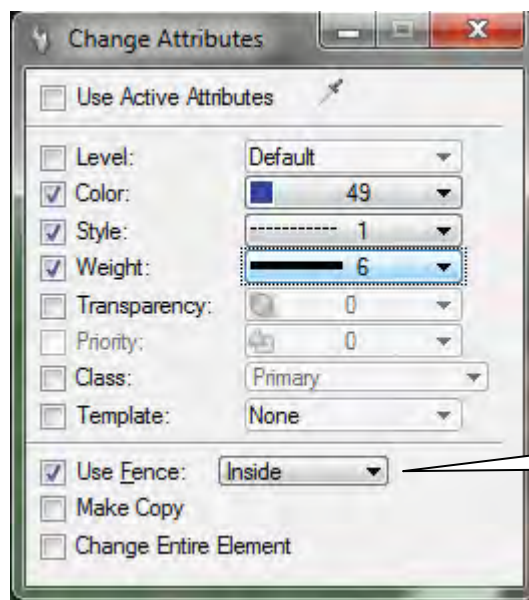


ID	Command	Contents	Action
M1: Selection	Element Selection	Select elements(one by one).	Click Icon then "Lmb" on a target element
M2: Fence	① Place Fence	Define area for Selection and Process.	Click Icon then "Lmb" at the Upper left of the area and Click "Left" at the Lower right
	② Modify Fence	Modify placed Fence	After place a fence, Click Icon then "Lmb" on the view and decide the size
	③ Manipulate Fence Contents	Copy, Move, Rotate elements inside Fence	After place a fence, Click Icon and choose manipulation then "Lmb" on the view and move cursor
	④ Delete Fence Contents	Delete elements inside Fence	After place a fence, Click Icon then "Lmb" on the view
	⑤- Advanced functions	"See Help"	
M3: Manipulate	① Copy	Copy selected element	Click Icon then "Lmb" on target element and after move cursor, "Lmb"
	② Move	Move selected element	Click Icon then "Lmb" on target element and after move cursor, "Lmb"
	③ Scale	Change size of selected element	Click Icon and set scale then "Lmb" on target element and after move cursor, "Lmb"
	④ Rotate	Rotate selected element	Click Icon and "Lmb" on target element then decide direction

	⑤-	Advanced functions	“See Help”	
M4: View Control	④	View Control	“See Chapter 1”	
M5: Change Attribute	①	Change Attribute	“See Chapter3.1”	“See Chapter3.1”
	②-	Advanced functions	“See Help”	
M6: Groups		Advanced functions	“See Help”	
M7: Modify		Modify	“See Chapter3.2”	“See Chapter3.2”
M8: Delete Element		Delete Element	Delete Element(one by one).	“Lmb” on target Element then "Lmb"

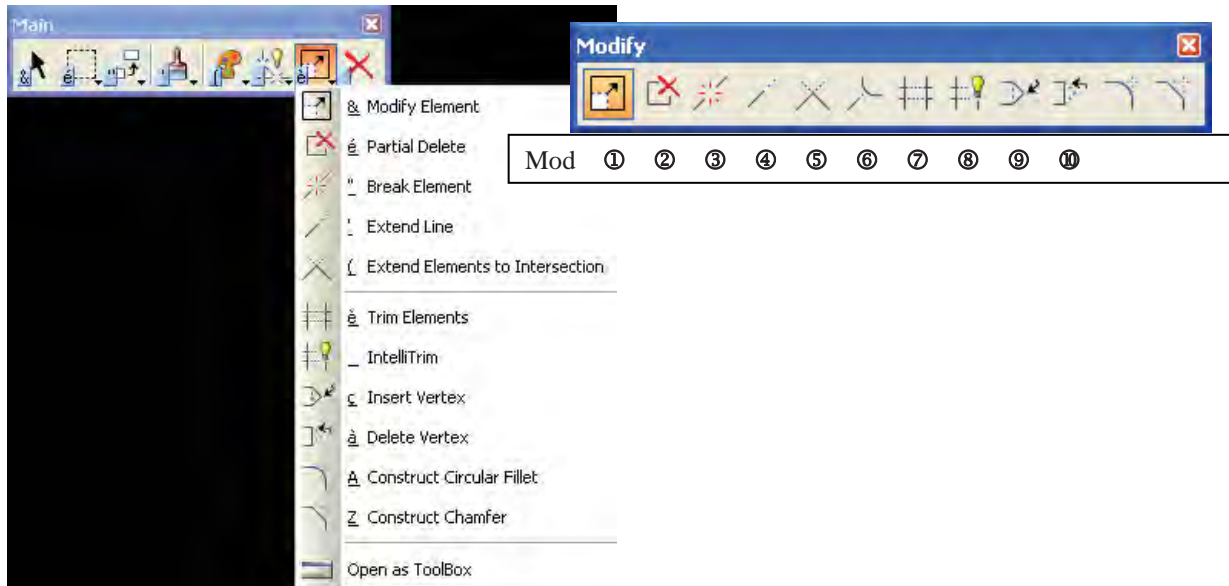
Notice: "See Help" means Go to "Help"-> "Tool Index" and Type keyword into "Index" Tag.

3.1 Change Attribute (Level, Color, Style, etc)



In case change several elements in the mean time

3.2 Modify (Extend, Trim, Delete etc)



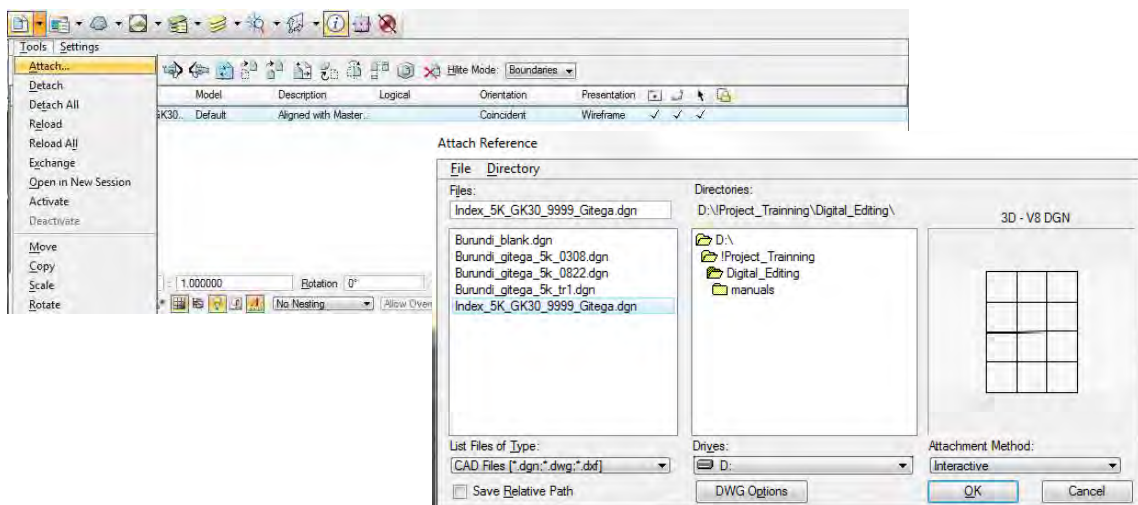
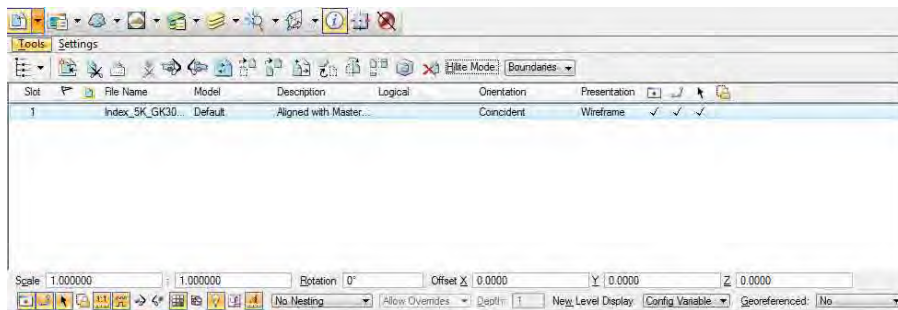
ID	Command	Contents	Action
Mod	①	Modify Element	Change the size of Element. Move a segment of Element.
	②	Partial Delete	Delete a section of a element.
	③	Break Element	Segment an element into several parts.
	④	Extend line	Extend a line to optional point.
	⑤	Extend element to intersection	Extend two lines to the cross point.
	⑥	Extend element to other element	Extend a line until target element.
	⑦	Trim elements	Delete element overshooted (One by One)
	⑧	Intelli Trim	Delete element overshooted (using line)
	⑨	Insert Vertex	Add new vertex into an element
	⑩	Delete Vertex	Delete vertex

4. Other useful Menu (From Primary Tools)

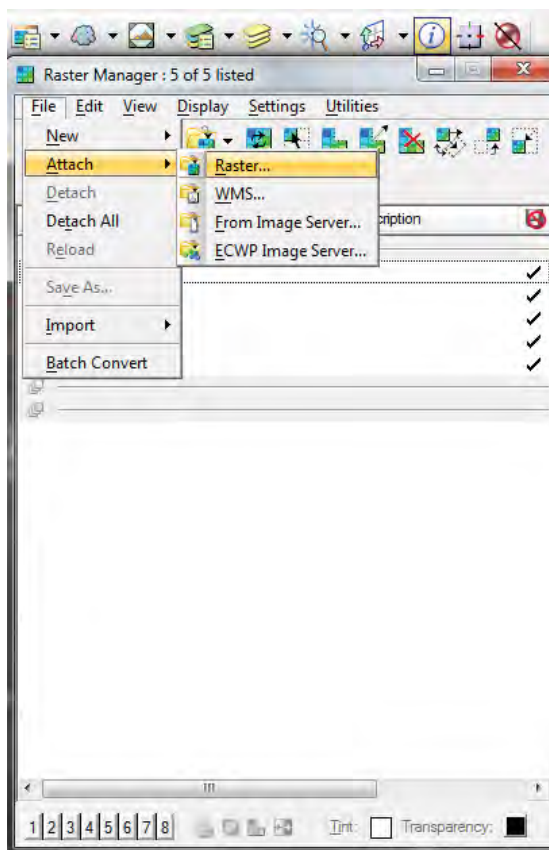


ID	Command Name	Contents	Action
P	①	References	Attach/Dettach other vector files(Dgn, Dxf, etc)
	②	Raster Manager	Attach/Dettach raster vector files(Tiff, Jpeg, etc)
	③	Level Manager	Control styles of elements in each level.
	④	Level display	Change ON/OFF on display by level.
	⑤	Element information	See Information of selected. Click Icon then “Lmb” on target element.

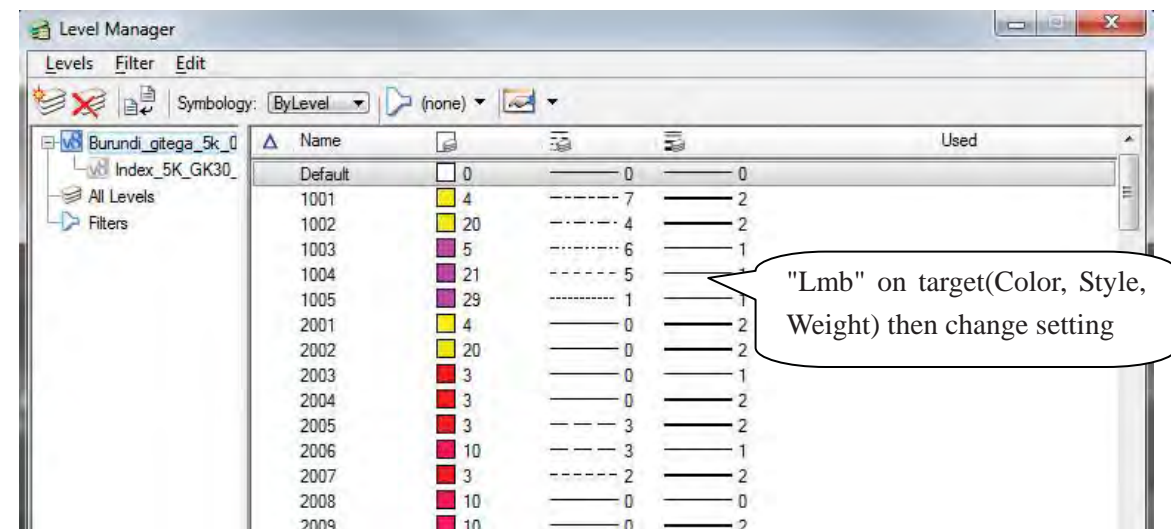
4.1 References



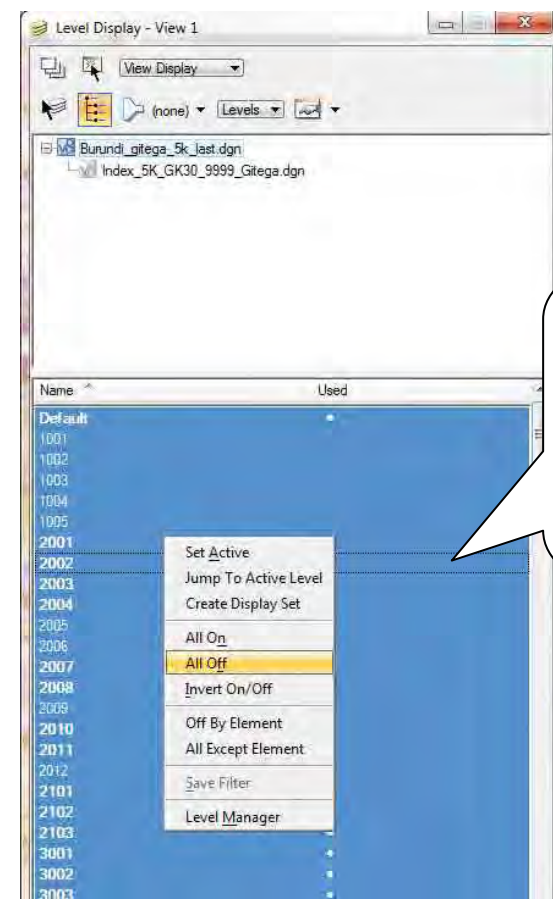
4.2 Raster Manager



4.3 Level Manager

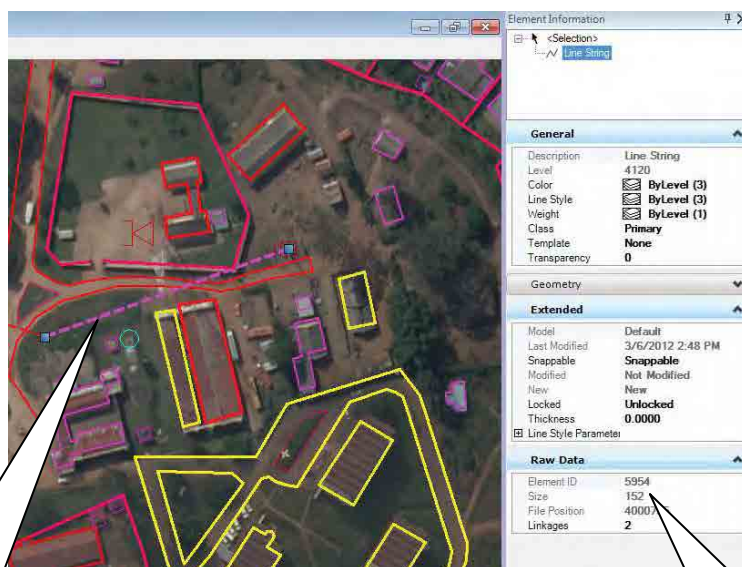


4.4 Level Display



Click "Mlb" and chnage ON/OFF with touching on Level Name
or
Click "Mrb" and Choose Options

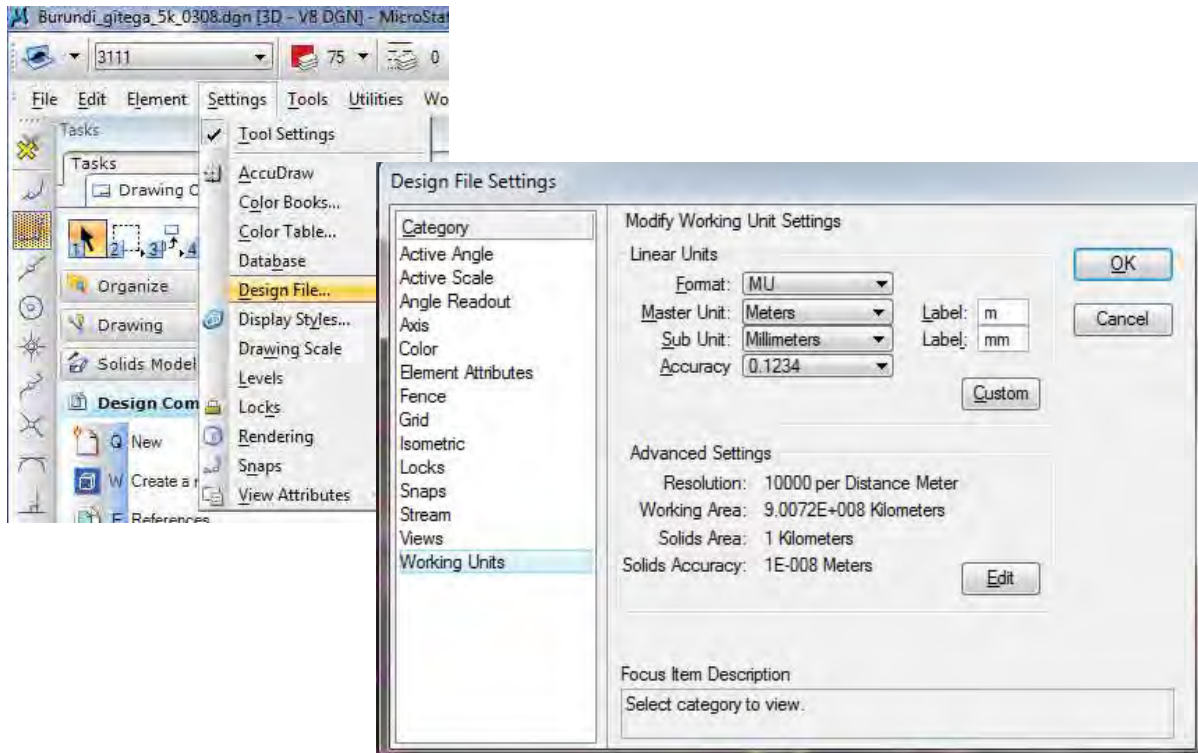
4.5 Element Information



Selected Element

Information

5. File setting



Instruction for compilation of plotted data

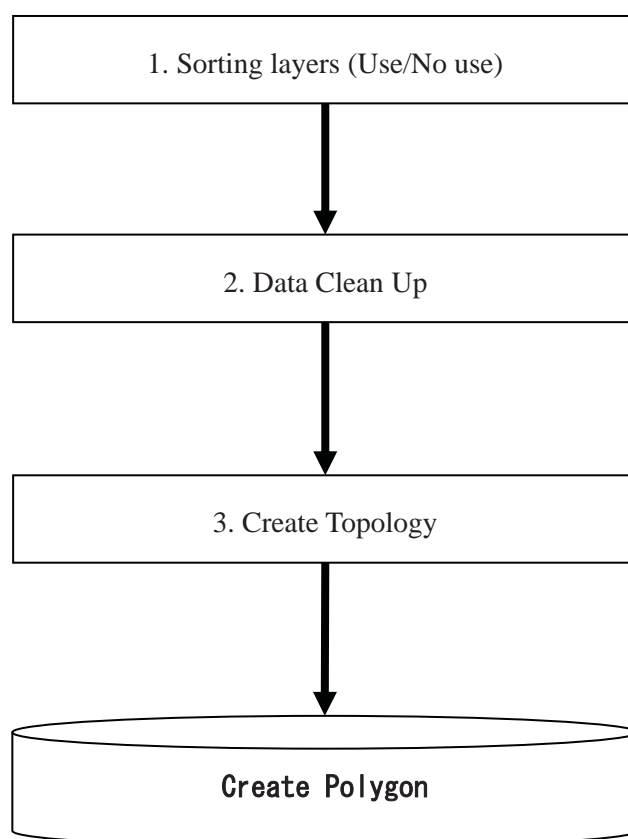
<Objective>

The objective of compilation in this project is creating polygon data for Cartography.

For creating polygons, "Data clean up" (Delete short elements, Delete Duplications, Fix Gaps and Dangles) and "Create Topology" are required.

<Work flow of Digital Compilation >

The flow in this work is following.



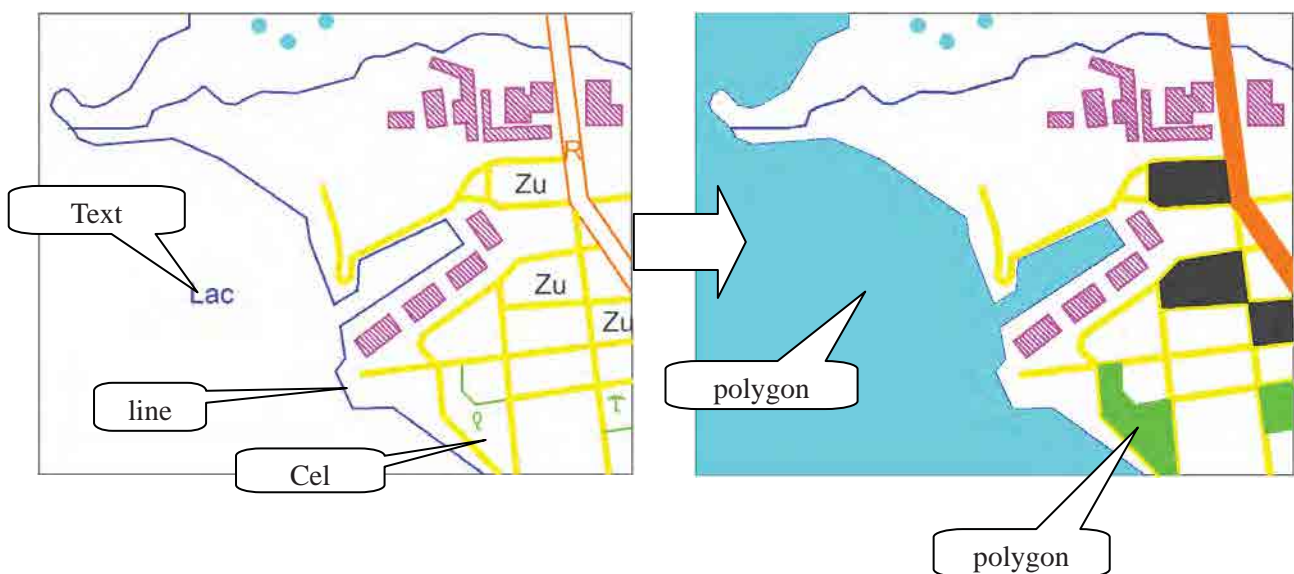
1. Sorting Layer

1.1 Type of data

There are 4 types of elements in the topographic data as follow.

Type of data	Explanation	Examples in this project		Remarks	
1	Line Smartline	Line composed more than 2 vertex	Administrative Boundary	Boundary of Commune (2001)	Used for the outline of Polygon
			Road	Unpaved road (2004)	
			River	Stream (5103)	
2	Point	Origin	Small Buildings	Primary school (3110)	Used to distinguish the area to be polygonized
	Cel (Symbol)		Small Structures	Antenne (4111)	
			Points Géodésique	Original Control point (7302)	
3	Text	Characters	Annotations		
			(Name of administrative area)	Administrative unit (8101)	
			(Name of Lake etc.)	Other toponym(8101)	
4	Polygon	Enclosed area	Paved road Vegetation area	Asphalt paved road (2001) Paddy field (6008)	Created by using of Data type 1-3

1.2 The theory of creation of polygon.



1.3 The part of each type of data

To know the classification of type for the generation of “Polygon”, See “Burundi_feature_catalog_5k.xls” and “Burundi_feature_catalog_25k.xls”.

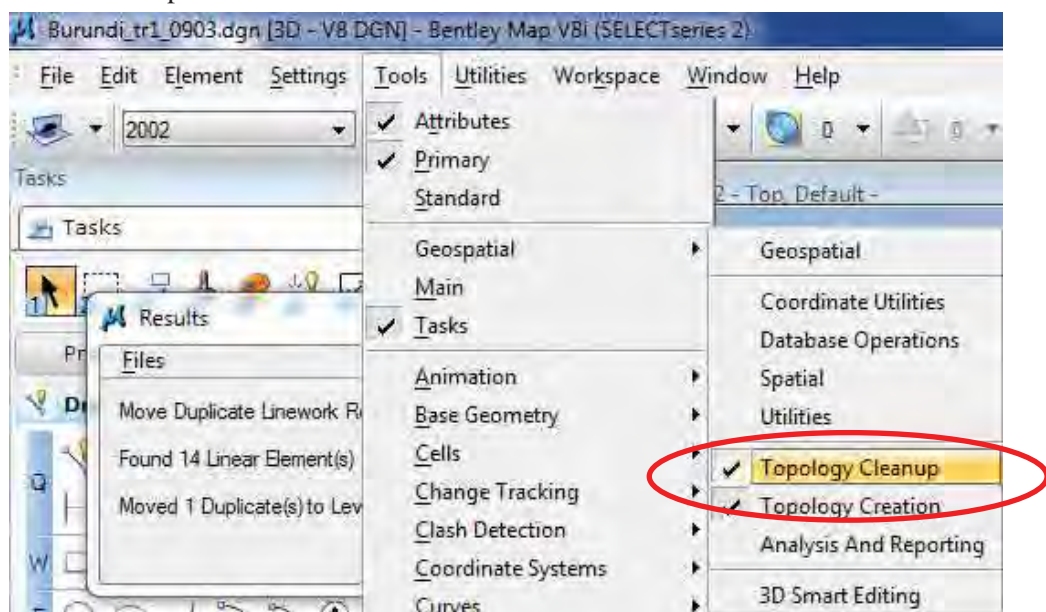
2. Data Cleaning

2.1 The manipulation to open the “Data clean up” Tool.

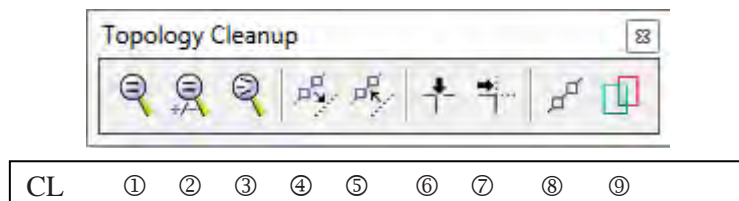
Open “BENTLAY MAP”

2.2 OPEN Data Clean up tool

Utilities > Data Clean Up

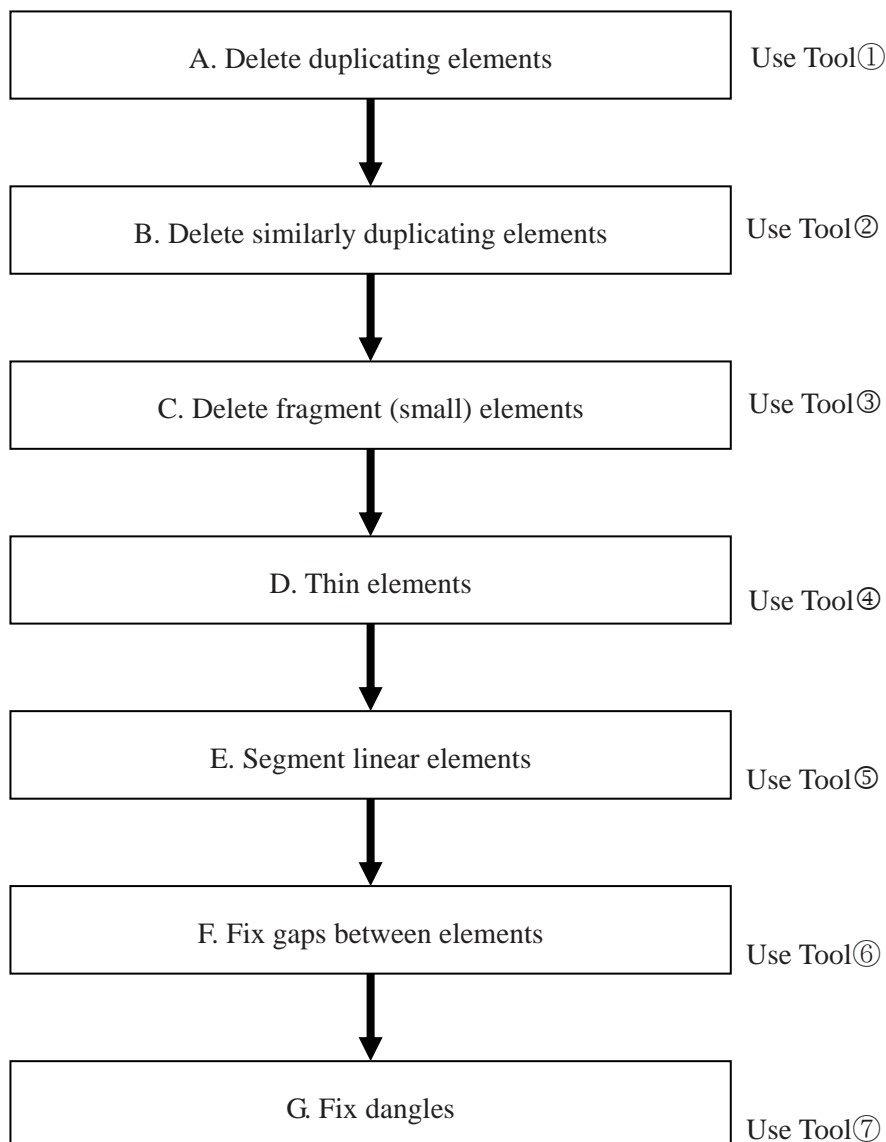


2.3 Clean up Tools



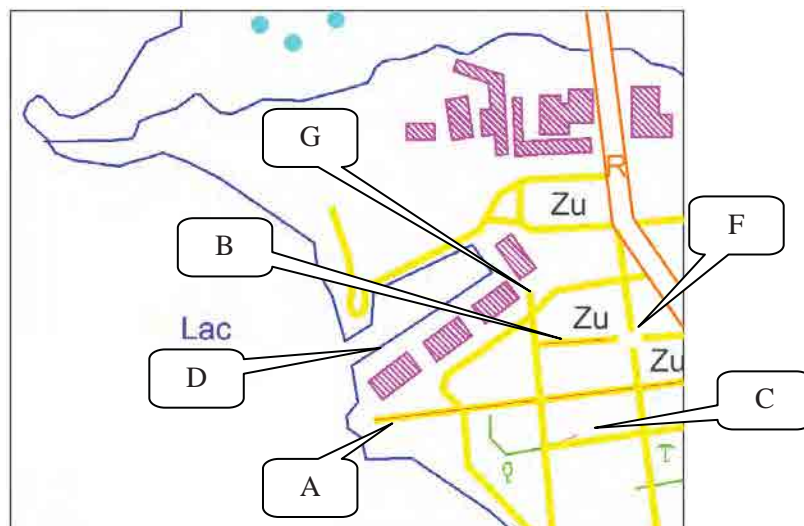
ID	Command Name	Contents	Action
CL	① Find duplicate linear elements	Find duplicate element and Delete or Move into Selected Level	Place Fence then Click Icon and set in the window then “Lmb”.
	② Find similar linear elements	Find similar element and Delete or Move into Selected Level	Place Fence then Click Icon and set in the window then “Lmb”.
	③ Find linear element fragments	Find small element(less than tolerance) and Delete or Move into Selected Level	Place Fence then Click Icon and set in the window then “Lmb”.
	④ Thin linear elements	Thin(mabiki) unnecessary smaller than tolerance	Place Fence then Click Icon and set in the window then “Lmb”.
	⑤ Segment linear elements	Separate elements(Break) on each cross point	Place Fence then Click Icon and set in the window then “Lmb”.
	⑥ Find gap	Find Gap element(less than tolerance) and Delete or Move into Selected Level	Place Fence then Click Icon and set in the window then “Lmb”.
	⑦ Find dangles	Find Dangle element(less than tolerance) and Delete or Move into Selected Level	Place Fence then Click Icon and set in the window then “Lmb”.
	⑧ Connect contiguous line work	Connect segmented elements into 1 element	Set Fence "Block" and "Overlap" then put Fence on the connection of target elements then “Lmb”.
	⑨ Find area slivers	Find small areas not required in the map then Merge or mark Flag	Place Fence then Click Icon and set in the window then “Lmb”.

2.4 The Workflow of “Data Clean up” and required “Tool”



2.5 The type of Errors shall be fixed in “Data Clean up” work.

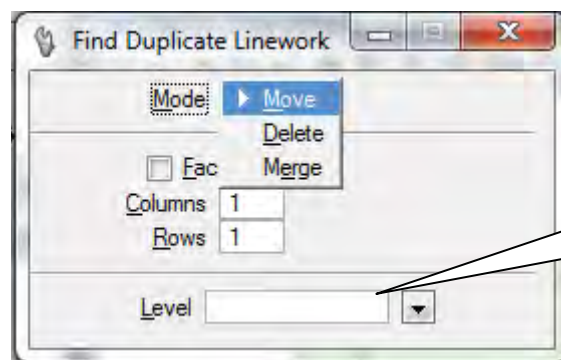
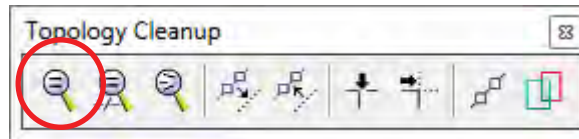
Classification of elements for Clean up		Examples	
		Before	After
A	Duplication		
B	similar linear elements		
C	Find linear element fragments		
D	Linear elements shall be thinned		
E	Segmentation		
F	Gap		
G	Dangle		



2.6 The Manipulation (Setting) of each “Data Clean up” tool.

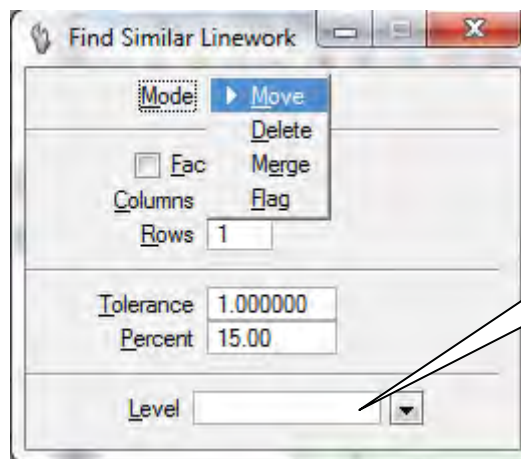
In case the errors shall be not delete but move into a “Level”, the “Level” (ex: name = “ERROR”) must be created before “Data Clean up”

A) Delete duplicating elements.



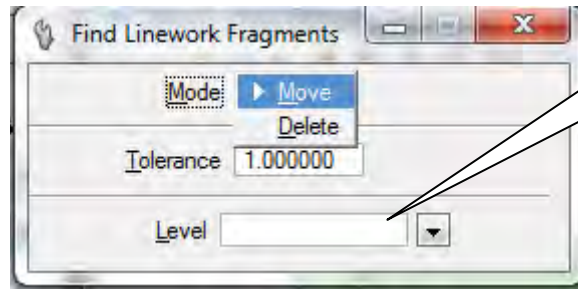
In case of "Move",
Choose Level to be
moved

B) Delete similarly duplicating elements



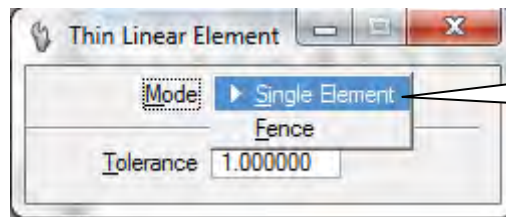
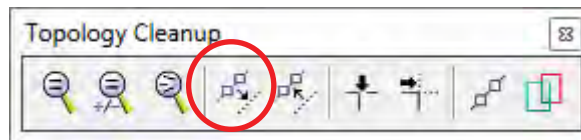
In case of "Move",
Choose Level to be
moved

C) Find linear element fragments



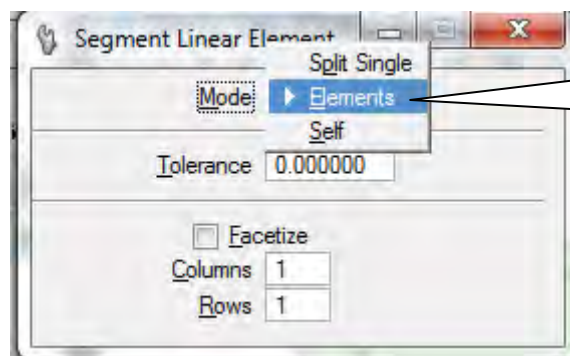
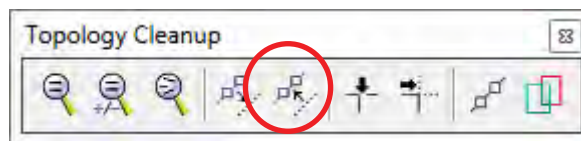
In case of "Move",
Choose Level to be
moved

D) Linear elements shall be thinned



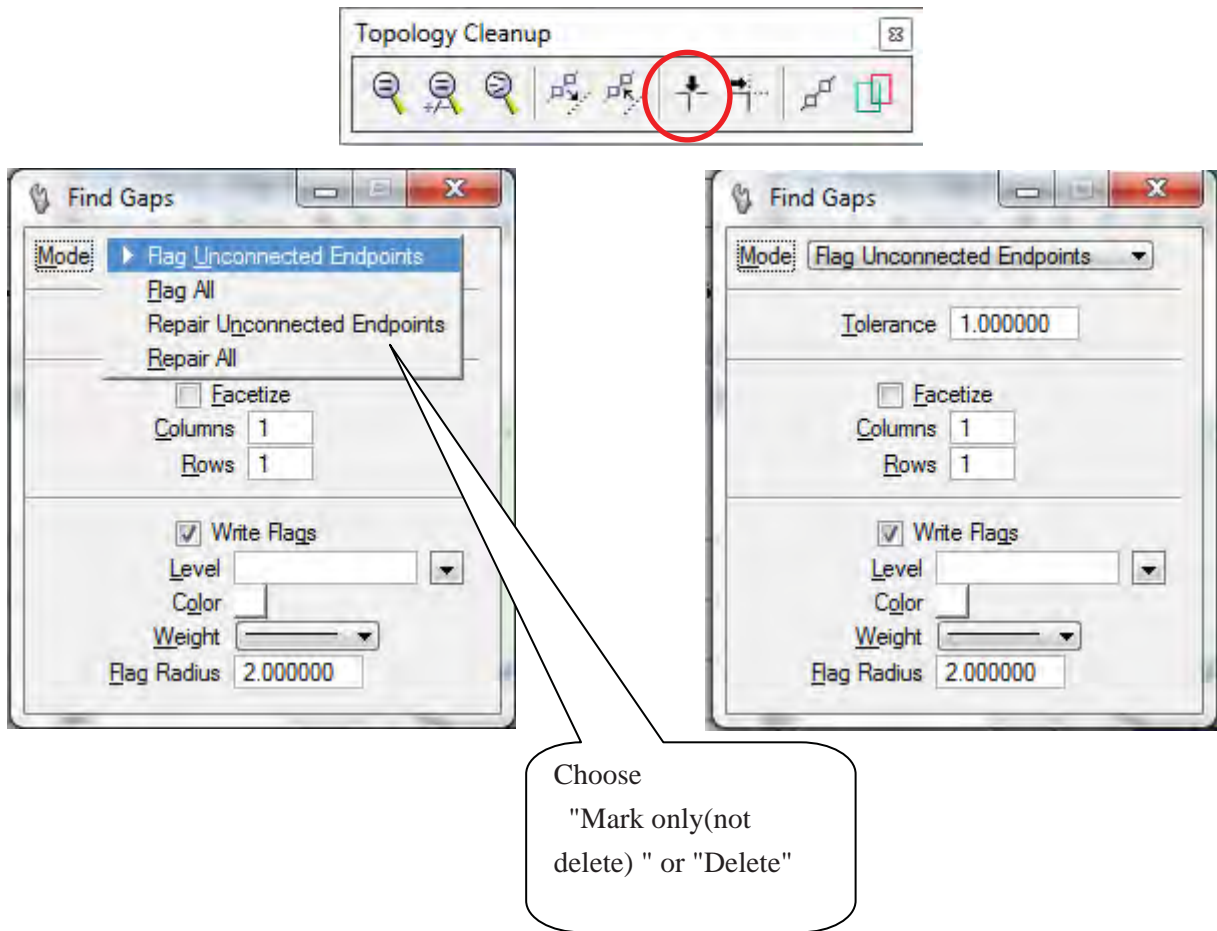
Choose "one by
one" or "all" inside
fence

E) Segmentation

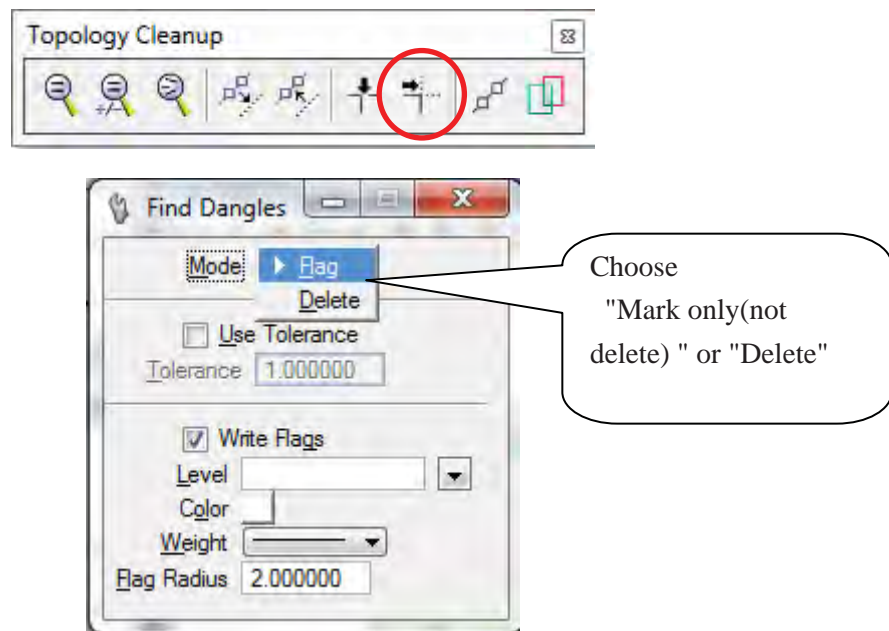


Choose "one by
one" or "all" inside
fence

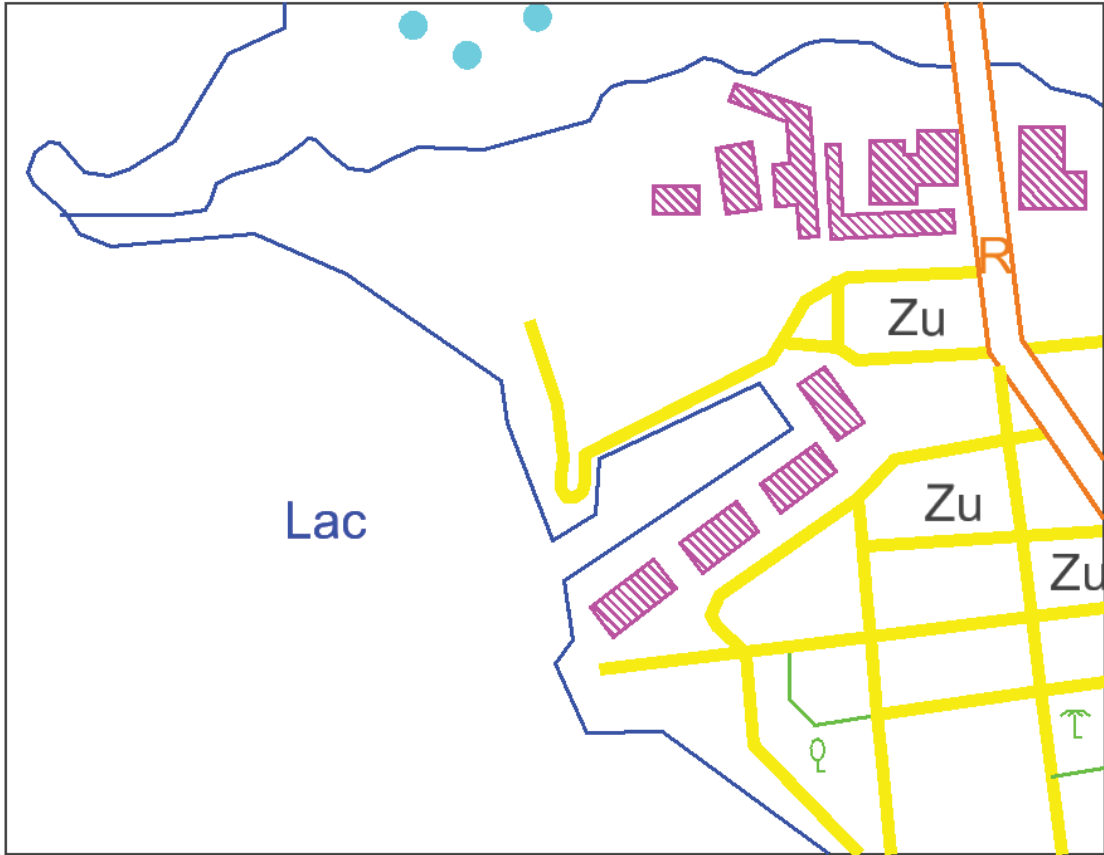
F) Find gap



G) Find Dangle



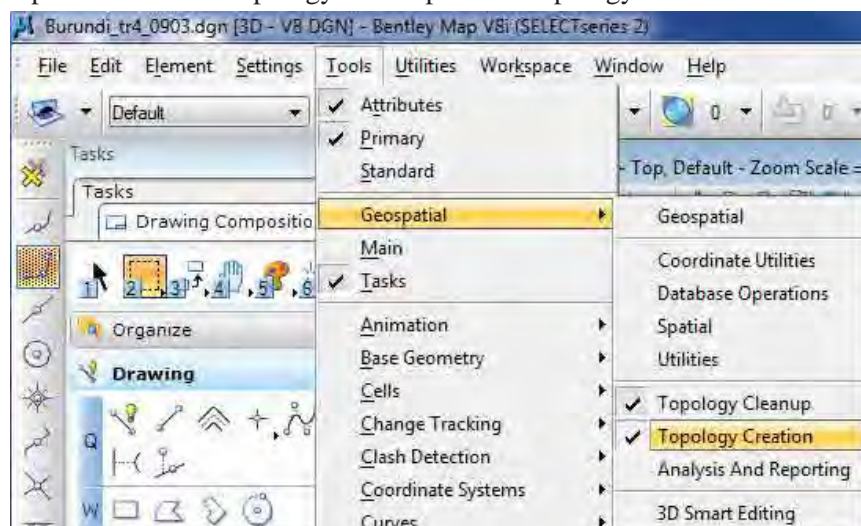
2.7 The result after “Data Clean up”.



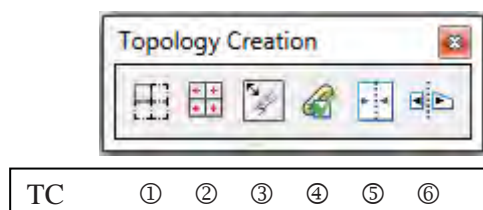
3. Create Topology

3.1 Create Topology

Open tool boxes “Topology Cleanup” and “Topology Creation”.

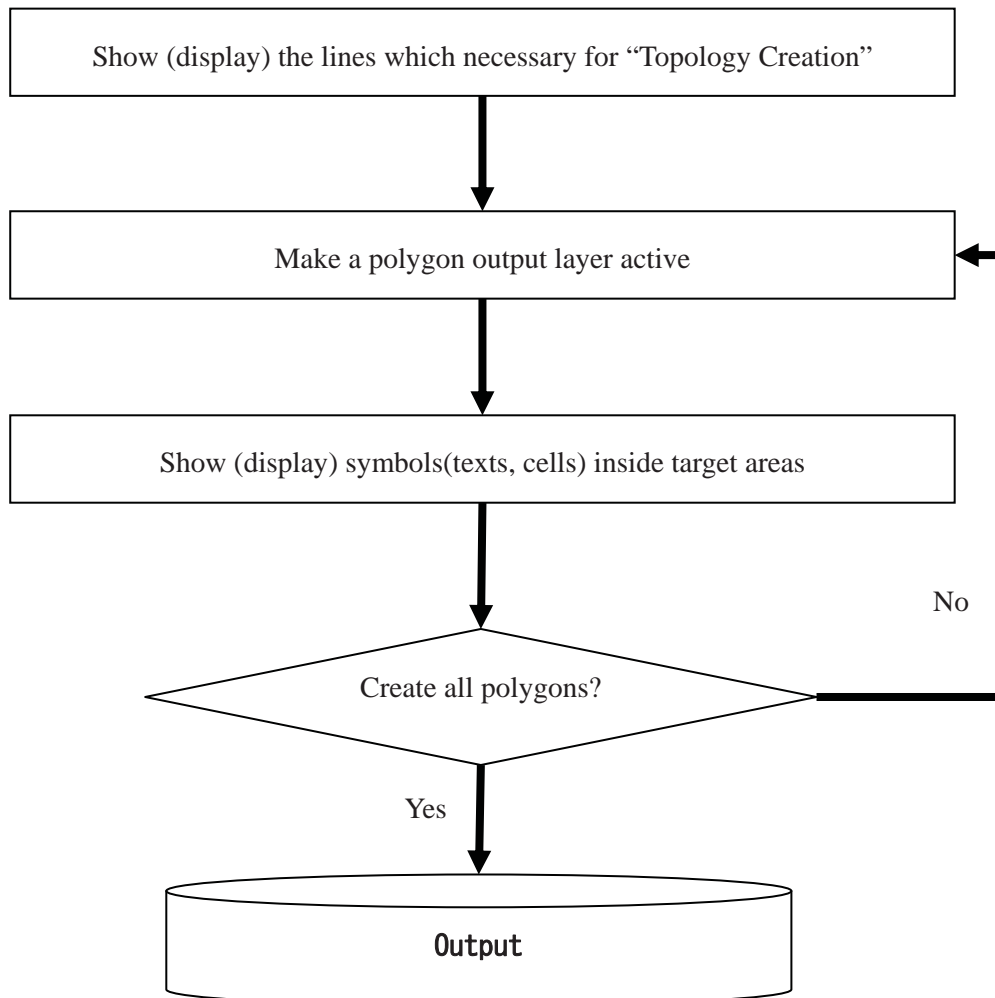


3.2 Polygon Creation I Tools



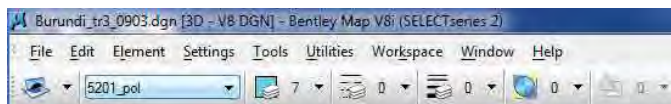
ID	Command Name	Contents	Action	
TC	①	Create shapes	Create shapes by "text" or "Cell" into active Layer	Place Fence then Click Icon and “Lmb”.
	②	Create centroids	Create Centroid inside closed area as the preparation for "Create shapes"	Place Fence then Click Icon and set in the window then “Lmb”.
	③	Associate Linkages	Advanced Function	
	④	Validate Topology	Detect the position of Topology	Place Fence then Click Icon and then “Lmb”.
	⑤	Merge Polygon	Merge some polygons into a polygon	Click Icon then Choose polygons shall be merged.
	⑥	Split Polygon	Split a polygon by line	Click Icon and Choose a polygon then Draw a line to Split.

3.3 Work flow of “Topology Creation”



3.4 The Manipulation (Setting) of each “Topology Creation” tool

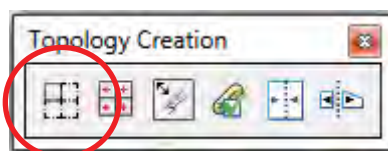
- 1). Select a level where polygon shall be created.



- 2). Show symbols (texts, cells) inside areas required to be created polygons into active layer.



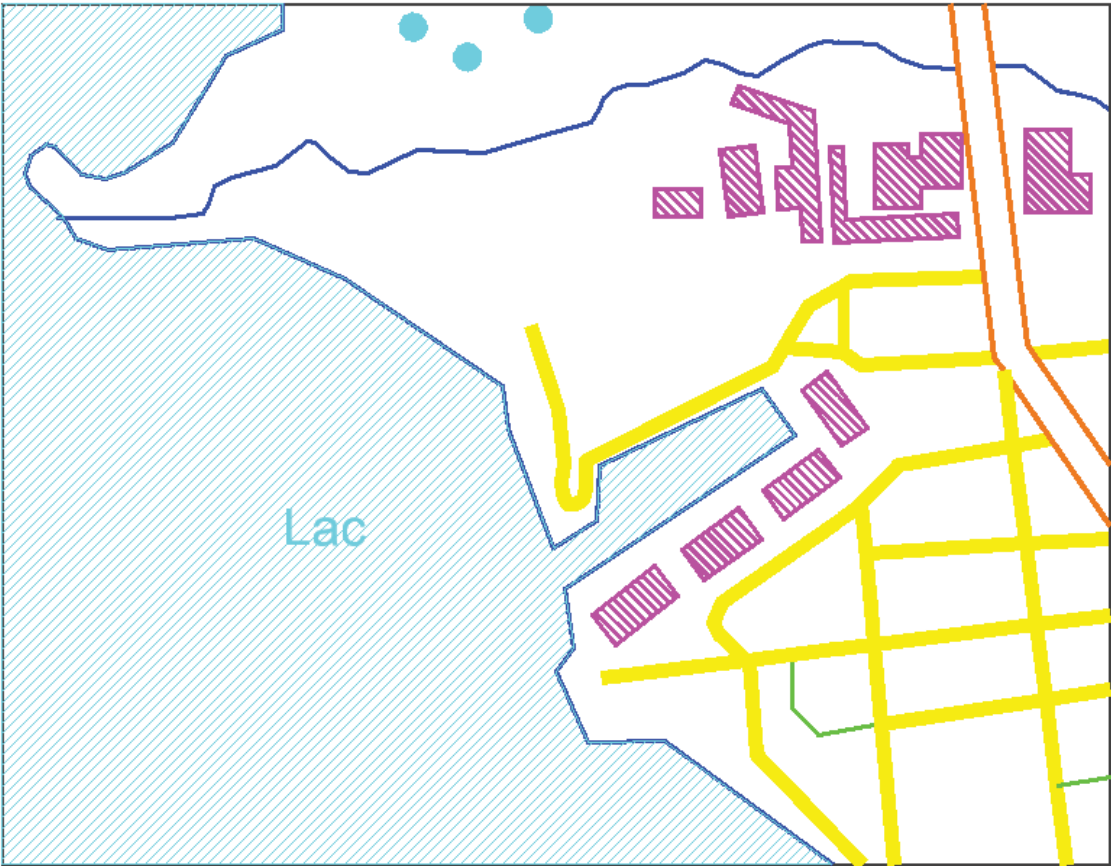
- 3). Place a Fence.
- 4). Click “Create shape” Icon.



- 5). “Lmb” on the view.

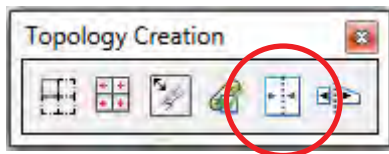


6). Check Result.

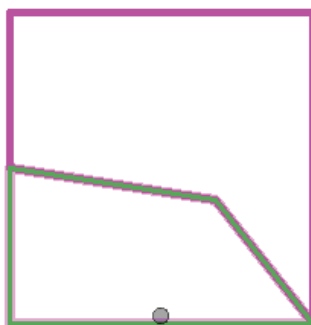
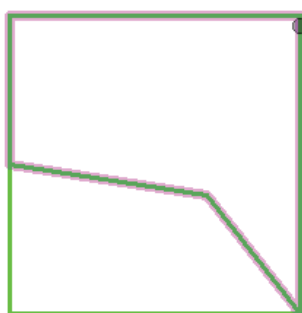


3.5 Merge and Split Polygons

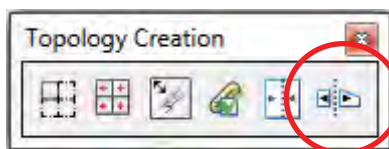
1). Merge Polygons



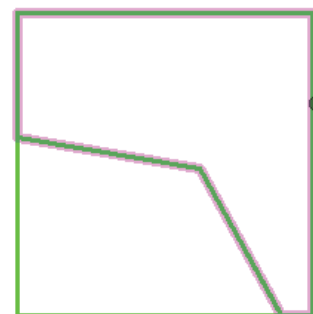
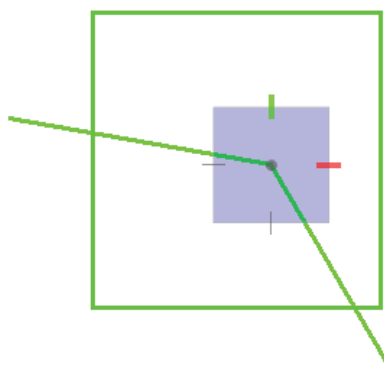
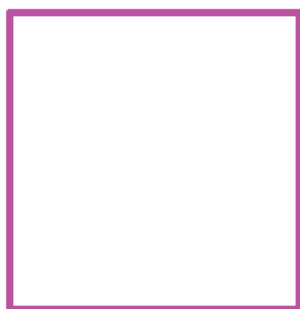
Identify element one by one >>> Lmb(out from element)



2). Split Polygon



Identify element >>> accept (Lmb) >>> Place "Cut line" >>> Rmb



Period